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Grassland

Project Protocol

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Abbreviations and Acronyms

AGC	Avoided grassland conversion
AGD	Animal grazing days
AOI	Area of Interest (within the NRCS Web Soil Survey application)
CARB	California Air Resources Board
CDL	Cropland Data Layer
CDM	Clean Development Mechanism
CFR	Code of Federal Regulations
CH_4	Methane
CO_2	Carbon dioxide
CRP	Conservation Reserve Program
CRT	Climate Reserve Tonne
CTIC	Conservation Tillage Information Center
DAYCENT	Daily CENTURY Model
EPA	U.S. Environmental Protection Agency
ERS	USDA Economic Research Service
ESA	Endangered Species Act
ESD	Ecological Site Description
FWS	U.S. Fish and Wildlife Service
GHG	Greenhouse gas
GPP	Grassland Project Protocol
GRP	Grassland Reserve Program
GWP	Global warming potential
HCP	Habitat Conservation Plan
ICC	Irrigated Land Capability Classification
IDB	Inventory Database (from the NRI)
IPCC	United Nations Intergovernmental Panel on Climate Change
IRT	The Army Corps of Engineers-led Interagency Review Team
ISO	International Organization for Standardization
lb	Pound
LCC	Land Capability Classification
MODIS	Moderate Resolution Imaging Spectroradiometer
MLRA	Major Land Resource Area designations

NARR	North American Regional Reanalysis Product
NASA	National Aeronautics and Space Administration
NASS	USDA National Agricultural Statistics Service
NICC	Non-Irrigated Land Capability Classification
NLCD	National Land Cover Database
N_2O	Nitrous oxide
NRCS	USDA Natural Resources Conservation Service
NRI	Natural Resources Inventory
PIA	Project Implementation Agreement
QCE	Qualified Conservation Easement
Reserve	Climate Action Reserve
SHA	Safe Harbor Agreement
SOC	Soil organic carbon
SSR	Source, sink, and reservoir
SSURGO	Soil Survey Geographic database
t	Metric ton (or tonne)
tCO_2e	Metric ton of carbon dioxide equivalent
UNFCCC	United Nations Framework Convention on Climate Change
USDA	United States Department of Agriculture
USGS	United States Geological Survey
WSS	NRCS Web Soil Survey application

1 Introduction

The Climate Action Reserve (Reserve) Grassland Project Protocol (GPP) provides guidance to account for, report, and verify greenhouse gas (GHG) emission reductions associated with projects that avoid the loss of soil carbon due to conversion of grasslands to cropland, as well as other associated GHG emissions. This protocol is designed to ensure the complete, consistent, transparent, accurate, and conservative quantification and verification of GHG emission reductions associated with an avoided grassland conversion project.[1]

The Reserve is an offset registry serving the California cap-and-trade program and the voluntary carbon market. The Reserve encourages actions to reduce GHG emissions and works to ensure environmental benefit, integrity, and transparency in market-based solutions to address global climate change. It operates the largest accredited registry for the California compliance market and has played an integral role in the development and administration of the state's cap-and-trade program. For the voluntary market, the Reserve establishes high quality standards for carbon offset projects, oversees independent third-party verification bodies, and issues and tracks the transaction of carbon credits (Climate Reserve Tonnes or CRTs) generated from such projects in a transparent, publicly-accessible system.[2] The Climate Action Reserve is a private 501(c)(3) non-profit organization based in Los Angeles, California.

Project Owners and Cooperative Developers that initiate avoided grassland conversion (AGC) projects use this document to quantify and register GHG reductions with the Reserve. The protocol provides eligibility rules, methods to calculate reductions, performance-monitoring instructions, and procedures for reporting project information to the Reserve. Additionally, all project reports receive independent verification by ISO-accredited and Reserve-approved verification bodies. Guidance for verification bodies to verify reductions is provided in the Reserve Verification Program Manual and Section 8 of this protocol. There are several additional resources which accompany this protocol document. Additional details for all of these resources can be found at the Grassland Project Protocol page on the Reserve's website: http://www.climateactionreserve.org/how/protocols/grassland/.

Resource	Required or Optional	Description
Grassland Project Parameters (MS Excel spreadsheet)	Required	This spreadsheet file contains parameters and emission factors which are required for the quantification of a grassland project. This includes stratum-level parameters, county-level parameters, and other necessary reference values. The parameters contained in this spreadsheet may be updated when new data becomes available. Stakeholders will be given advanced notice and guidance before updated parameters become effective for projects.
GrassTool v2.0 (MS Excel spreadsheet)	Optional	The GrassTool is built upon the quantification section of this protocol, allowing for Project Owners to conduct project quantification without first developing their own tool. It is updated periodically to enhance usability or correct errors.

[1] See the WRI/WBCSD GHG Protocol for Project Accounting (Part I, Chapter 4) for a description of GHG reduction project accounting principles.
[2] The online registry may be accessed from the Reserve homepage at: www.climateactionreserve.org.

Resource	Required or Optional	Description
Project Development Handbook (PDF)	Optional	This document provides additional context and description for the rules and requirements contained in the protocol. It is not considered to be official protocol language, and is not meant to be a standard of verification. It is informal guidance to help understand protocol requirements, and it is updated periodically.

2 The GHG Reduction Project

This section describes the GHG reduction project in terms of defining the project site, the related activities, the parties involved, and the possible project structures.

2.1 Background

Grasslands have the ability to both emit and sequester carbon dioxide (CO_2), the primary GHG responsible for human-caused climate change (1). Grasses and shrubs, through the process of photosynthesis, naturally absorb CO_2 from the atmosphere and store the gas as carbon in their biomass (i.e., plant tissues). As plants die and regrow, some of this carbon is also stored in the soils that support the grassland.

When grasslands are disturbed, such as when the land is tilled for crop cultivation, a portion of the stored carbon oxidizes and decays, releasing CO_2 into the atmosphere. The quantity and rate of CO_2 that is emitted may vary, depending on the particular circumstances of the land and the disturbance. Grasslands function as reservoirs in the global carbon cycle. Depending on how grasslands are managed or impacted by natural and human events, they can be a net source of emissions, resulting in a decrease to the reservoir, or a net sink, resulting in an increase of CO_2 to the reservoir. In other words, grasslands may have a net negative or net positive impact on the climate, depending on their characteristics and management.

Through sustainable management and protection, grasslands can play a positive and significant role to help address global climate change. This protocol is designed to take advantage of grasslands' unique capacity to sequester, store, and emit CO_2 and to facilitate the positive role that grasslands can play to address climate change. The protocol focuses on the avoided conversion of grasslands to cropland. Because conversion is avoided, we can never measure the exact GHG impacts of conversion activities on the project area, and thus cannot know exactly how much carbon would have been released if a particular area of land were converted. To avoid the cost and uncertainty related to site-specific soil sampling and ecosystem modeling, the Reserve has adopted a standardized, probabilistic approach to estimating baseline emissions for AGC projects. This approach is discussed in more detail in Section 5, as well as Appendix B.

2.2 Project Definition

For the purpose of this protocol, the GHG reduction project is defined as the prevention of emissions of GHGs to the atmosphere through conserving grassland belowground carbon stocks and avoiding crop cultivation activities on an eligible project area, as initiated by the recording of a perpetual conservation easement or an eligible transfer of ownership, as described in Section 3.2. The project area must be grassland, as defined below, and it must be suitable for conversion to crop cultivation, as defined in Section 3.3.1.2. The project area must have been in continuous grassland cover for at least 10 years prior to the project start date. The baseline scenario for all AGC projects is conversion to crop cultivation.

For the purposes of this protocol, grassland is defined as an area of land dominated by native or introduced grass species with little to no tree canopy. Other plant species may include woody shrubs, legumes, forbs, and other non-woody vegetation. Tree canopy may not exceed 10% of the land area on a per-acre basis. Areas that exceed this threshold may be eligible to use the

Forest Project Protocol.[3] For the purposes of this protocol, grassland may include managed rangeland and/or pastureland (as defined in Section 9).

There must be common ownership for the entire project area (i.e., it must be possible to protect the project area through a single conservation easement). Multiple projects may be managed together as a project cooperative, as described in Section 2.2.2. In addition, the project area must have been privately-owned prior to the project start date, except in the case of non-federal public lands, where:

- The project area is legally able to be converted to cropland without requiring a rulemaking activity; and either
- The public agency in charge of management of the project area must have a legal directive to manage the lands that include the project area for profit; or
- A history of such management for profit,[4] including existing conversion, for similarly-situated lands can be documented during the 10 years prior to the start date.

An AGC project may involve moderate levels of seeding, organic fertilizer application (i.e., manure, compost, etc.), haying, forage harvesting, livestock grazing and/or irrigation as part of the project activity. Projects may not employ synthetic fertilizer additions; CRTs will not be issued for any calendar year during which this occurs. If grazing is employed in the project scenario, the livestock manure must not be managed in liquid form (i.e., containing less than 20% dry matter and subject to active management), and grazing activities must meet the criteria in Section 6.2.

Other recreational or economic activities incidental to the project activities may also occur on the project area (e.g., hunting, bird-watching, light haying), but only to the extent that the incidental activity does not threaten the integrity of the soil carbon stocks and is otherwise compatible with the maintenance of grassland under conservation. The Reserve maintains the right to determine whether an activity is “incidental” to the project or whether the presence of the activity would cause part or all of the project area to be considered an entirely different land use (i.e., not grassland). In those cases, the area used for such activities may not be considered to be part of the project area. For example, the extensive conversion of grasslands to forage crop production may result in that activity no longer being considered incidental to the project, and the subject land no longer eligible to be part of the project area.

The project lifetime for an AGC project is up to 150 years. This includes the crediting period, which may be up to 50 years (Section 3.4) and the permanence period, which is the 100 years following the crediting period (Section 3.5).

2.2.1 Defining the Project Area

An eligible project area consists of grassland that meets the criteria in Section 3 regarding the threat of conversion to cropland and the lack of legal barriers to such conversion. Only areas that are suitable for conversion to cropland, as defined in Section 3.3.1, are eligible to report under this protocol. The entire project area must be able to be protected by the recording of a single conservation easement (see Section 3.5.1). The area bound by the conservation

[3] Information regarding the Reserve’s voluntary forest carbon program can be accessed at: http://www.climateactionreserve.org/how/protocols/forest/. Information regarding the California Compliance Offset Protocol for forest projects can be accessed at: http://www.climateactionreserve.org/how/california-compliance-projects/compliance-offset-projects/.

[4] A practice of carrying out all leasing and sales based on fair market value may be considered “management for profit.”

easement does not need to match the project area. However, the entire project area must be included within the area of the conservation easement. A single project may include multiple legal parcels if all of these conditions can be met. The project does not need to contain every parcel listed on a deed, and project boundaries do not necessarily need to be coincident with parcel boundaries (i.e., the project area may contain a portion of a parcel without necessarily including the entire parcel).

The geographic boundaries defining the project area must be described in detail at the time a grassland project is listed on the Reserve (see Section 7.2 for details on project documentation). The boundaries must be defined using a georeferenced map, or maps, that displays legal property boundaries, public and private roads, major watercourses (fourth order or greater), topography, towns, and public land survey townships, ranges, and sections or latitude and longitude. The maps should be of adequate resolution to clearly identify the required features. The shapes delineating the project area must contain only areas that meet the eligibility requirements of this protocol. If the project area contains more than one legal parcel, these delineations must also be included. This map is not publicly accessible.

A Geographical Information System file (GIS shapefile) must be submitted to the Reserve with the project documentation. The shapefile may be converted to a KML file. The acres reported for the project must be based on the acres calculated from the shapefile. The project area can be contiguous or separated into tracts, but must share common ownership and project start date. See Section 5.1 for guidance regarding the stratification of the project area.

After the project has been verified, sections of the project area may be removed (subject to the requirements of Section 5.4), but the project area may not be expanded. New projects may always be added to a project cooperative (see Section 2.3.4).

2.2.2 Project Cooperative

A "project cooperative" or "cooperative" is a collection of two or more individual grassland projects managed by a common entity (referred to as the "Cooperative Developer," Section 2.3) that engage in joint monitoring, reporting, and verification (Sections 6.4, 7.6, and 8.1).

2.3 Project Ownership Structures and Terminology

A grassland project can be implemented using various ownership structures. Figure 2.1 displays possible ownership structures for grassland projects, indicating the flow of information and which entities are required to hold Reserve accounts. These are simplified representations; actual project and cooperative structures may be more complex, but the relationships follow the same approach.

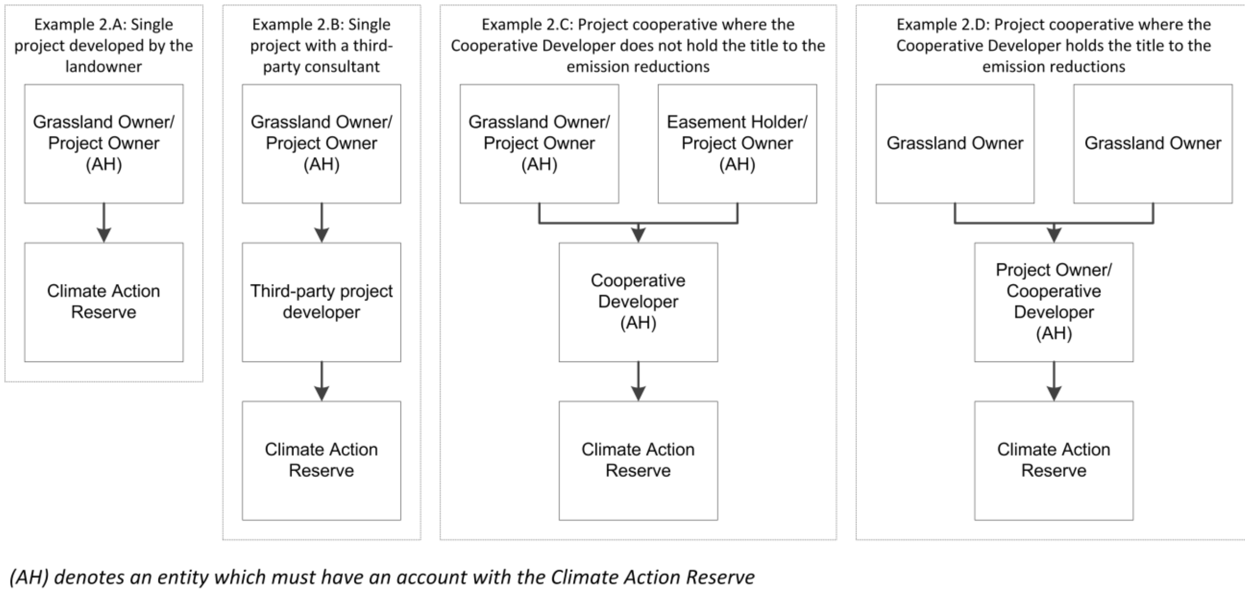

Figure 2.1. Grassland Project Ownership Structures and Terminology

Depending on the project structure, the existence and/or status of certain legal instruments must be verified in order to successfully register a project. The instruments required are described in general below. For every project, the fee owner of the land on which the project is implemented must demonstrate an understanding of the potential participation in a carbon offset program, either through implementing a project himself, or through clear conveyance of the GHG reduction rights associated with the land through a recorded legal instrument as described below. The sections outlined in Table 2.1 should be referred to for specific requirements for each respective legal instrument required. Additional discussion of these legal instruments can be found in Appendix D.

Table 2.1. Guide to Protocol Sections Related to Legal Instruments for Grassland Projects

Legal Instrument	Protocol Section(s)
GHG reduction rights contract	2.3.2
Indemnification agreement	2.3.2
Conservation easement	2.2, 3.2, 6.2.1.2
Qualified Conservation Easement	3.5.1
Project Implementation Agreement	3.5.2
Reserve attestations (title, voluntary implementation, regulatory compliance)	2.3.2, 3.3.2, 3.6
Instruments associated with concurrently-joined conservation programs	3.3.2.1

2.3.1 Qualifications and Role of Grassland Owners

A Grassland Owner is an individual or a corporation or other legally constituted entity, city, county, state agency, or a combination thereof that has fee ownership and legal control of the land within the project area. A lessee is not a Grassland Owner. Deeded encumbrances that exist within the project area may prevent a fee owner from satisfying the definition of a Grassland Owner. The Grassland Owner is the entity that has the authority to execute and record a conservation easement on the project area. Any unencumbered soil carbon is presumed to be controlled by the fee owner. Notwithstanding this presumption, the Reserve maintains the right to determine whether an individual or entity meets the definition of Grassland Owner.

2.3.2 Qualifications and Role of Project Owners

A Project Owner is the entity that holds legal title to the emission reductions related to the grassland project, and is responsible for undertaking the grassland project and registering it with the Reserve. The Project Owner may be a Grassland Owner, a holder of a conservation easement on the property, or they may be a third-party entity who has a signed contract with the Grassland Owner conveying title to the emission reductions. Title to the emission reductions may be conveyed through the conservation easement or in a separate contract, but in any case such rights must be legally established. If there are any Grassland Owners who are not party to the GHG reduction rights agreement, the Project Owner must also execute an indemnification stating that they will indemnify the Reserve in connection with any claims brought by other grassland owners or would-be grassland owners against the Reserve.[5] The Project Owner shall execute the Project Implementation Agreement (PIA) (see Section 3.5.2). The Project Owner is also responsible for the accuracy and completeness of all information submitted to the Reserve, and for ensuring compliance with this protocol, even if the Project Owner contracts with an outside entity to carry out these activities. The Project Owner must have a Reserve registry account[6] and must sign all required legal attestations (e.g., Attestation of Title, Attestation of Voluntary Implementation, and Attestation of Regulatory Compliance). Sample language related to ownership of emission reductions is included below, to be amended to fit each project's specific situation:

> *"TITLE TO CARBON OFFSET CREDITS. The [grantor/grantee- i.e., whichever party to the easement or agreement is the Project Owner] hereby retains, owns, and holds legal title to and all beneficial ownership rights to the following (the "Project Reductions"): (i) any removal, limitation, reduction, avoidance, sequestration or mitigation of any greenhouse gas associated with the Property including without limitation Climate Action Reserve Project No. [___] and (ii) any right, interest, credit, entitlement, benefit or allowance to emit (present or future) arising from or associated with any of the foregoing, including without limitation the exclusive right to be issued carbon offset credits or Climate Reserve Tonnes (CRTs) by a third party entity such as the Climate Action Reserve."*

In all cases, the Project Owner must attest to the Reserve that they have exclusive claim to the GHG reductions resulting from the project. Each time a project is verified, the Project Owner must attest that no other entities are reporting or claiming (e.g., for voluntary reporting or regulatory compliance purposes) the GHG reductions caused by the project.[7] The Reserve will not issue CRTs for GHG reductions that are reported or claimed by entities other than the Project Owner (e.g., grassland owners who are not the Project Owner). In the case of project cooperatives, each Project Owner must sign an attestation. Attestations may be submitted by a third party, but must be signed by the Project Owner.

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[5] A sample indemnification agreement is available at: http://www.climateactionreserve.org/how/protocols/grassland/.
[6] Information regarding Reserve accounts and the process for project submittal and registration is available here: http://www.climateactionreserve.org/how/projects/register/.
[7] This is done by signing the Reserve's Attestation of Title form, available at: http://www.climateactionreserve.org/how/program/documents/

A Project Owner who will be managing the submittal, reporting, and verification of the grassland project through their own Reserve account will open a Project Developer account. A Project Owner whose project will be managed as part of a cooperative, and who will not be utilizing their Reserve account for any action beyond outgoing transfers of CRTs, will open a Project Owner account.

Project Owners are ultimately responsible for timely submittal of all required forms and complying with the terms of this protocol. Project Owners may designate a technical consultant or Cooperative Developer to manage the flow of documents and information to the Reserve. The scope of services provided by a technical consultant or Cooperative Developer should be determined by the Project Owner and the relevant management entity and reflected in the contracts between the Project Owner and the relevant management entity.

2.3.3 Qualifications and Role of Cooperative Developers

A "Cooperative Developer" is the entity that manages reporting and verification for a project cooperative, i.e., two or more individual grassland projects that report and verify jointly. A cooperative may consist of grassland projects involving multiple Project Owners. A Cooperative Developer must have an account on the Reserve.

A Cooperative Developer must open a Project Developer account on the Reserve and must remain in good standing throughout the duration of the cooperative(s) it manages. Failure to remain in good standing will result in all account activities of the participant projects in the cooperative(s) managed by that Cooperative Developer being suspended until issues are resolved to the satisfaction of the Reserve. In order for a Cooperative Developer to remain in good standing, Cooperative Developers must perform as follows:

- Complete cooperative contracts with Project Owners (see following section on Joining a Cooperative)
- Engage the services of a single verification body for all grassland projects enrolled in the cooperative in any given verification period
- Coordinate the submittal, monitoring, and reporting activities required by this protocol for all projects in the cooperative(s), observing all cooperative deadlines
- Coordinate a verification schedule that maintains appropriate verification status for the cooperative. Document the verification work and report to the Reserve on an annual basis how completed verifications demonstrate compliance (see Sections 6.4, 7.6, and 8.1)
- Maintain a Reserve account in good standing

As discussed in Section 2.3.2, Project Owners are ultimately responsible for timely submittal of all required forms and complying with the terms of this protocol.

2.3.4 Forming or Entering a Cooperative

Individual grassland projects may join a cooperative by being included in the cooperative's Cooperative Submittal Form[8] (if joining a cooperative at initiation) or by being added through the submission of a New Grassland Project Enrollment Form (if joining once the cooperative is underway).

[8] All forms referenced in this section are available at: http://www.climateactionreserve.org/how/program/documents/.

The Cooperative Developer will initiate the creation of the cooperative by submitting a Cooperative Submittal Form. The Cooperative Submittal Form includes the submittal information for all of the individual projects to be initially included in the cooperative. If the Cooperative Developer is not the Project Owner for one or more projects within the cooperative, the appropriate Project Owner account will be confirmed at the time of project submittal. All documentation related to the cooperative and its participant projects is submitted by the Cooperative Developer. After successful verification, CRTs are issued to the accounts of the Project Owners for each project.

Individual grassland projects that have already been submitted to the Reserve may choose to join an existing cooperative by submitting a Cooperative Transfer Form to the Reserve. The Cooperative Developer must also submit a New Project Enrollment Form, listing that project area, if the cooperative is already underway. Emission reductions occurring on individual projects or new projects entering a cooperative are reported as part of the cooperative during the reporting period in which the transfer occurred.[9] The project will begin reporting with the cooperative no earlier than the beginning of the cooperative's current verification period. If the project has already been registered, either as an individual project or as part of another cooperative, reporting under the new cooperative may not include any period of time that has already been reported and verified.

The crediting periods of the individual projects within a cooperative are derived from their individual project start dates, and are not affected by the crediting periods of other projects within the cooperative. All projects within a cooperative must follow the same version of this protocol. If a project that is subject to a more recent version of the protocol wishes to enter an existing cooperative, the rest of the projects in that cooperative must elect to upgrade to the newer version of the protocol.

2.3.5 Leaving a Cooperative

Individual grassland projects must meet the requirements in this section in order to leave or change cooperatives and continue reporting emission reductions to the Reserve. Reporting must be continuous.

Individual Project Owners may elect to leave a cooperative and participate as an individual grassland project for the duration of their crediting period, effective as of the day after the end date of the project's most recently registered reporting period. To leave a cooperative and become an individual grassland project, the Project Owner must submit a Project Submittal Form to the Reserve, noting that it is a "transfer project" and identifying the cooperative from which it is transferring. For projects which leave a cooperative to become an individual project, the deadline for submittal of the subsequent monitoring or verification report (whichever is sooner) is extended by 12 months beyond the deadline specified in Section 7.4. The Project Owner must submit either a monitoring report or verification report (whichever is due) by this new deadline in order to keep the project active in the Reserve. If the Project Owner has a Project Owner account in the Reserve at the time they leave the cooperative, they must contact the Reserve Administrator to set up a Project Developer account.

To leave one cooperative and enter another cooperative, the Project Owner must submit a Cooperative Transfer Form to the Reserve prior to enrolling in the new cooperative. Reporting under the destination cooperative shall continue according to the guidance in Section 7.6.1.

[9] The transfer is considered to have occurred once the Reserve has approved the Cooperative Transfer Form and the New Project Enrollment Form.

2.4 Environmental Best Management Practices

The Grassland Project Protocol is intended to generate GHG reductions through the avoided conversion of grassland to cultivated cropland. The protocol also seeks to limit potential environmental harms caused by project activities through the requirements for regulatory compliance specified in Section 3.6. Environmental enhancements in addition to GHG reductions are beyond the scope of this document. However, the Reserve does strongly encourage Project Owners and Grassland Owners to adopt practices that provide additional benefits to the grassland ecosystem beyond the GHG reductions. Project Owners and Grassland Owners are encouraged to review and implement the appropriate recommendations for rangeland management developed by the United States Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) Conservation Effects Assessment Project (2). It is furthermore recommended that best management practices relevant to the project area be included as terms of the conservation easement and/or the GHG reduction rights contract.

3 Eligibility Rules

Projects must fully satisfy the following eligibility rules in order to register with the Reserve. The criteria only apply to projects that meet the definition of a GHG reduction project (Section 2.2).

Eligibility Rule I:	Location	→	*Conterminous U.S. and tribal areas*
Eligibility Rule II:	Project Start Date	→	*No more than six months prior to project submission*
		→	*Record a conservation easement or eligible transfer of ownership*
		→	*Cooperative start date options*
Eligibility Rule III:	Additionality	→	*Meet performance standard*
		→	*Exceed legal requirements*
		→	*Satisfy credit and payment stacking requirements*
Eligibility Rule IV:	Project Crediting Period	→	*Emission reductions may only be reported during the crediting period, up to a maximum of 50 years*
Eligibility Rule V:	Permanence	→	*Maintain stored carbon for at least 100 years following issuance of CRTs*
		→	*Employ a Qualified Conservation Easement and Project Implementation Agreement*
Eligibility Rule VI:	Regulatory Compliance	→	*Compliance with all applicable laws*
Eligibility Rule VII:	Rangeland Health	→	*Periodic monitoring and adaptive management*

3.1 Location

Only projects located in the conterminous United States and on U.S. tribal lands are eligible to register reductions with the Reserve under this protocol. All sources within the project boundary (Figure 4.1) must be located within the conterminous United States. Under this protocol, reductions from international projects are not eligible to register with the Reserve. Grassland projects in tribal areas must demonstrate that the land within the project area is owned by a tribe or private entities. Projects are not eligible on organic soils (histosols),[10] including areas identified as wetlands or peatlands.

In addition, the project area must be located on land whose particular combination(s) of Major Land Resource Area (MLRA), soil texture, and prior land use history would result in emissions of soil carbon in the baseline scenario. To be eligible, the grassland project must be able to generate emission reductions through project activities. This is determined by identifying the project strata following the guidance in Section 5.1. The project location is ineligible if there are

[10] Wherever soil types or characteristics are referenced in this protocol, they shall be assumed to describe the upper 20 cm soil layer, unless otherwise specified.

no baseline emission reductions from soil organic carbon in the first 10-year emission factor period.[11]

3.2 Project Start Date

The project start date is defined as the date on which the project area is committed to the long-term management and protection of grassland and therefore avoids conversion to cropland.

Commitment to long-term management and protection of grassland must be demonstrated by one of the following:

1. Submitting the project to the Reserve.[12] Note that the project must meet the tests for additionality as of the project start date. Thus, this option is not applicable if the project is submitted after the recordation of a conservation easement covering the project area.
2. Recordation of a conservation easement on the project area, with a provision to maintain the project area as grassland for the protection of soil carbon. The project start date is the date the easement was recorded. If an easement is amended to meet the requirements of a Qualified Conservation Easement (Section 3.5.1), the recordation date of the unamended easement may be used for purposes of determining the project start date. If the Project Owner intends to use the date of recordation of the amended easement as the project start date, they must be able to show that, prior to amendment, the original conservation easement would not have violated any provisions of the legal requirement test (Section 3.3.2).
3. Transferring of property ownership to a public or private entity with a provision that the project area be maintained as grassland for the protection of soil carbon. The project start date is the date of property transfer. Projects whose start dates rely on the transfer of ownership to an entity other than the Federal Government are still required to record a conservation easement, as described above, prior to the initial registration.

To be eligible, the project must be submitted to the Reserve no more than six months after the project start date, unless the project was submitted for listing prior to July 22, 2016.[12]

Projects that have previously been submitted to and accepted by another offset project registry (transfer projects) may be eligible with a historic start date. Start date requirements for those projects are described in the Reserve Program Manual.[13] Projects may always be submitted for listing by the Reserve prior to their start date.

3.3 Additionality

The Reserve strives to register only projects that yield surplus GHG reductions that are additional to what would have occurred in the absence of a carbon offset market.

Projects must satisfy the following criteria to be considered additional:

1. The performance standard test
2. The legal requirement test

[11] Certain parameters required for project eligibility and quantification are contained in a separate document, *Grassland Project Parameters*, available at: http://www.climateactionreserve.org/how/protocols/grassland/.
[12] Projects are considered submitted when the Project Developer has fully completed and filed the appropriate Project Submittal Form, available at: http://www.climateactionreserve.org/how/program/documents/.
[13] Please refer to the most current version of the Reserve Program Manual, available at: http://www.climateactionreserve.org/how/program/program-manual/.

3. Limits on payment and credit stacking

3.3.1 The Performance Standard Test

Projects pass the performance standard test by meeting a performance threshold, i.e,. a standard of performance applicable to all grassland projects, established by this protocol. The performance standard test is applied at the time a project applies for registration with the Reserve. The performance standard test for a grassland project has two parts:

1. Financial threshold
2. Suitability threshold

3.3.1.1 Financial Threshold

The Reserve has determined that there is a financial barrier to project activities due to the economic incentives to convert grassland to cropland. Rather than have each project demonstrate the existence of this barrier individually, the Reserve has developed a standardized threshold for financial additionality, referred to as the cropland premium. The cropland premium is determined as the percentage difference in the value (represented by land rental rates in $/acre) of cropland over pastureland in the county where the project is located. Project eligibility is based on the cropland premium for the county where the project is located, based on the conditions below:

1. Projects in counties with a cropland premium greater than 100% are eligible without any discount for uncertainty
2. Projects in counties with a cropland premium greater than 40% but less than 100% are eligible, but must apply a discount to their baseline emissions (see Section 5.2.4 for a description of DF_{conv}), unless the county can meet the requirements of step 4
3. Projects in counties with a cropland premium less than 40% are not eligible, unless the project meets the requirements of step 4
4. Projects in counties that meet the description of step 2 or step 3, or which are identified in the tables as having "No Data," have the option to obtain a certified appraisal to determine a site-specific cropland premium, following the guidelines below for the appraisal process.

If more than 10% of the project area is located in a particular county, then eligibility must be assessed separately for that county. If the county is not eligible, then that portion must be removed from the project area. If less than 10% of the project area is located in an ineligible county, that area may be included in the project area as long as it is physically contiguous with a portion of the project area which is located in an eligible county. A document and a spreadsheet with the eligibility status of each county are available from the Reserve website.[14] A paper copy of this list will be provided upon request. The standardized financial threshold will be updated whenever new rental rate data are published by the NASS. The new table of county-specific parameters will be published prior to the date on which the new values become effective.[15] When new tables are published, guidance will be given regarding the effective date. Figure 3.1 displays the county eligibility for projects submitted after December 31, 2016 (until such time as a new table and guidance are published by the Reserve). For counties that are identified as

[14] Certain parameters required for project eligibility and quantification are contained in a separate document, *Grassland Project Parameters*, available at: http://www.climateactionreserve.org/how/protocols/grassland/.

[15] Typically, rental rate data are released in September, in which case the Reserve will publish a new table in October with an effective date of January 1 of the following year. However, this could change if the NASS adopts a different schedule for data release.

having no data, a Project Owner may request that the Reserve examine the data for surrounding counties and determine whether the county may be considered eligible (and the appropriate value for DF_{conv}, if applicable). Additional information regarding the development of this threshold can be found in Appendix A.

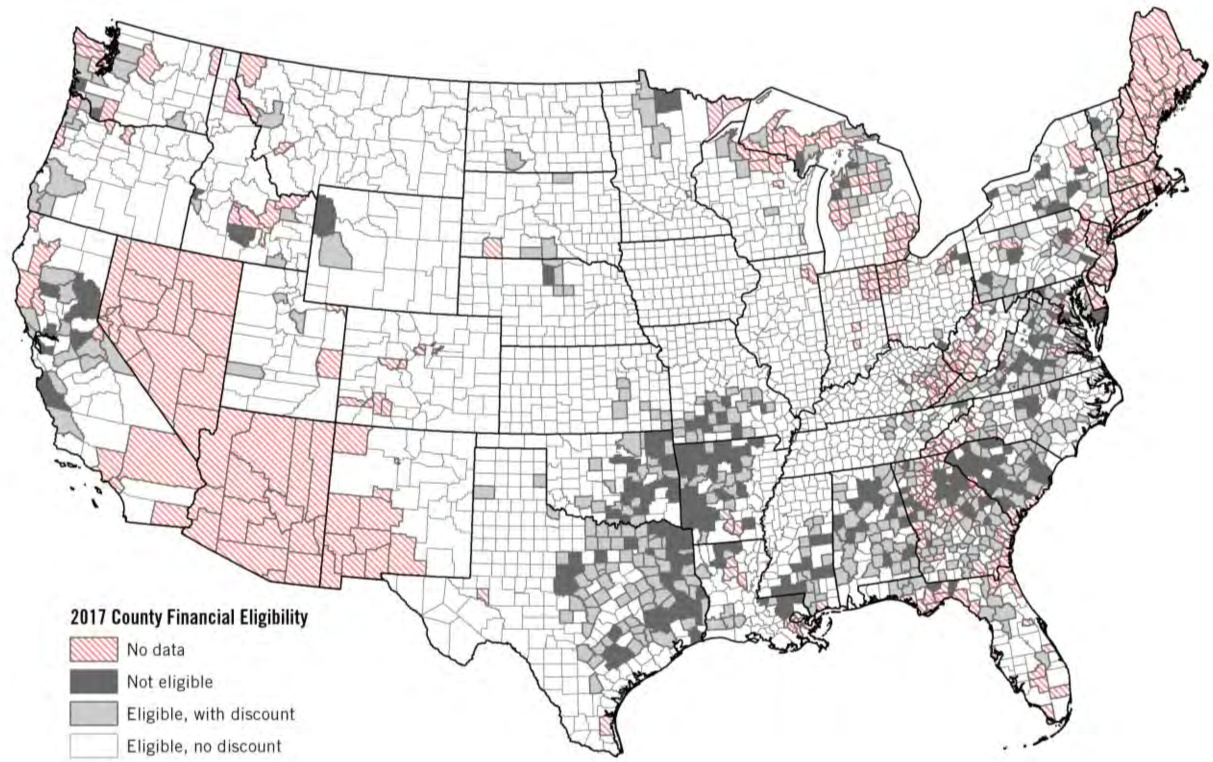

Figure 3.1. County Eligibility Map for Projects Submitted after December 31, 2016

Appraisal Option

If using step 4 above, a project may satisfy the financial threshold if the Project Owner provides an up-to-date[16] real estate appraisal for the project area (as defined in Section 2.2.1) indicating the following:

1. *The project area is suitable for conversion to cropland*. The appraisal must clearly indicate how the physical characteristics of the project area are suitable for crop cultivation, including the particular crops expected to be grown.
2. The appraisal must conform with the following minimum standards[17]:
    a. Appraisal reports shall be prepared and signed by a third-party, Licensed or Certified Real Estate Appraiser in good standing.
    b. Appraisal reports shall include descriptive photographs and maps of sufficient quality and detail to depict the subject property and any market data relied upon, including the relationship between the location of the subject property and the market data. The appraisal must provide a map that displays specific portions of the project area that are suitable for crop production. (For example, an appraisal

[16] An appraisal will be considered "up-to-date" if it is finalized no more than12 months before or after the project start date.
[17] Adapted from Sections 5096.501 and 5096.517, Public Resources Code, State of California.

that identified corn production as an alternative land use must specify the approximate acres suitable for both the crops and any related roads, buildings, or other infrastructure.)

c. Appraisal reports shall include a complete description of the subject property land, site characteristics and improvements. Valuations based on a property's development potential shall include:
   i. Verifiable data on the conversion potential of the land (e.g., Certificates of Compliance, Tentative Map, Final Map, approval for crop insurance, new breakings request form).
   ii. A description of what would be required for a conversion to cropland to proceed (e.g., legal entitlements, infrastructure).
   iii. Presentation of evidence that sufficient demand exists, or is likely to exist in the future, to provide market support for the conversion to cropland.
   iv. The appraisal must demonstrate that the slope of project area land is compatible with crop production by identifying two areas with similar average slope conditions to the project area within the project's MLRA that are currently in crop cultivation.
   v. The appraisal must also provide:
      1. Evidence of soil suitability for the type of expected agricultural land use.
      2. Evidence of water availability for the type of expected agricultural land use.

d. Appraisal reports shall include a statement by the appraiser indicating to what extent land title conditions were investigated and considered in the analysis and value conclusion.

e. Appraisal reports shall include a discussion of implied dedication, prescriptive rights or other unrecorded rights that may affect value, indicating the extent of investigation, knowledge, or observation of conditions that might indicate evidence of public use.

f. Appraisal reports shall include a separate valuation for ongoing grassland management prepared and signed by a certified or registered professional qualified in the field of specialty interest. This valuation shall be reviewed and approved by a second qualified, certified or registered professional, considered by the appraiser, and appended to the appraisal report. The valuation must identify and incorporate all legal constraints that could affect the valuation of the ongoing grassland management.

g. The appraisal must be conducted in accordance with the Uniform Standards of Professional Appraisal Practice[18] and the appraiser must meet the qualification standards outlined in the Internal Revenue Code, Section 170 (f)(11)(E)(ii).[19]

3. *The alternative land use for the project area has a higher market value than maintaining the project area for sustainable grassland management, such that it meets the financial additionality threshold.* The appraisal for the property must provide an estimated fair

[18] The Uniform Standards of Professional Appraisal Practice may be accessed at: http://commerce.appraisalfoundation.org/html/2006%20USPAP/toc.htm

[19] Section 170 (f)(11)(E) of the Internal Revenue Code defines a qualified appraiser as "an individual who:
(I) has earned an appraisal designation from a recognized professional appraiser organization or has otherwise met minimum education and experience requirements set forth in regulations prescribed by the Secretary,
(II) regularly performs appraisals for which the individual receives compensation, and
(III) meets such other requirements as may be prescribed by the Secretary in regulations or other guidance."

market value for the rental rate (in US$ per acre per month) for the current grassland use condition of the project area (considering the land to be encumbered and thus unable to be converted to cropland) and an estimated fair market value of the rental rate for the anticipated use the project area as cropland. The appraisal must identify whether or not irrigation is considered in the valuation (or, alternatively, may provide estimations both with and without irrigation). The difference between the rental rate for cropland and the rental rate for grassland, divided by the rental rate for grassland, is the cropland premium for the project area. Eligibility is then determined according to the thresholds as outlined in the beginning of Section 3.3.1.1.

3.3.1.2 Suitability Threshold

The project area must be suitable for conversion to cropland. Suitability is demonstrated by determining the Land Capability Classification (LCC) for the soil map units that are contained within or intersect the project area. Soil map units and their corresponding characteristics, such as LCC, are defined in the Soil Survey Geographic Database (SSURGO).[20] The LCC is divided into eight classes of decreasing value as cropland, with LCC I-IV being considered generally suitable for cultivation (3). SSURGO contains LCC for both irrigated and non-irrigated land uses. The Project Owner shall refer to the non-irrigated LCC (NICC) to determine eligibility for the project area. If a Project Owner would like to use the irrigated LCC (ICC) for a project, they must provide evidence that the project area would have access (both legal and physical) to irrigation in the baseline scenario. This can be demonstrated by one or more of the following methods, subject to the verifier's professional judgment:

- Comprehensive assessment of the existence of available groundwater,[21] and the legal and economic feasibility of the Grassland Owner to access it from within the project area
- Documentation of the current availability of water rights and/or permits for the project area on or around the project start date
- Documentation of installation of new irrigation on lands within the project county within the 24 months prior to the project start date
- Evidence of ongoing irrigation practice on other parcels within the county

Grassland projects are generally only eligible on LCC I-IV soils, with allowances for a limited amount of LCC V-VI soils. LCC VII-VIII soils are not eligible for crediting. This protocol offers two options for determining the allowable amount of LCC V-VI soils in the project area: a default MLRA-specific threshold or an assessment of the LCC of local cropland. Project Owners may select either of the two options below.

Option 1: Default Land Capability Classification Threshold Based on Major Land Resource Area

The Reserve has developed a table of default, MLRA-specific LCC thresholds. The specific default value for each MLRA is contained in the *Grassland Project Parameters* spreadsheet.[22] The percentage of cultivated land that is classified as NICC I-IV (rounded to the nearest whole number) represents the minimum allowable percentage of the project area for those land classes. For example, if the default value is 80%, the threshold for eligibility for that MLRA is

[20] Additional background and details regarding SSURGO may be found at: http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/survey/?cid=nrcs142p2_053627 (accessed 10/27/16).
[21] The groundwater assessment should be completed by an appropriately-trained professional, such as a Professional Geologist, Professional Engineer, or Certified Hydrogeologist.
[22] Certain parameters required for project eligibility and quantification are contained in a separate resource, *Grassland Project Parameters*, available at: http://www.climateactionreserve.org/how/protocols/grassland/.

80% NICC I-IV, allowing for up to 20% NICC V-VI. Please see Appendix A for a description of how these thresholds were derived.

The default MLRA-specific thresholds are calculated using the NICC. Certain MLRAs with high levels of irrigation also have a default threshold provided based on the ICC. Project Owners have the option of applying the default NICC threshold, using the NICC values for their project area, or the default ICC threshold, using the ICC values for their project area. Use of the ICC values is subject to the requirements above to demonstrate access to irrigation in the baseline scenario.

Option 2: Local Cropland Assessment

In areas where the Project Owner believes that the option above does not accurately reflect the LCC of local cropland, a local assessment may be carried out. The assessment must include at least three actively-cultivated farms in the same county, with the individual acreage of each farm being no less than the total acreage of the project area, and must include the entire area under cultivation for each property, excluding areas that are not used for crop cultivation. For each property the Project Owner shall identify the NICC of the soil map units, add up the acreage for each NICC across all properties in the assessment, and determine the percentage by area for NICC I-IV land. The fraction of cultivated land that is classified as NICC I-IV (rounded to the nearest whole number) represents the minimum allowable fraction of the project area for those land classes. This analysis may be conducted using the ICC values, in which case the Project Owner must follow the requirements above to demonstrate access to irrigation in the baseline scenario. Project Owners are strongly encouraged to consult with Reserve staff when conducting an assessment under this option.

3.3.2 The Legal Requirement Test

All projects are subject to a legal requirement test to ensure that the GHG reductions achieved by a project would not otherwise have occurred due to federal, state, or local regulations, or other legally binding mandates. The legal requirement test for grassland projects involves three parts to ensure the project activity is allowed but not compelled:

1. There must be no federal, state, or local regulation for the project area to be maintained as grassland, either pre-existing or subsequent, or other pre-existing legally binding mandate, agreement, contract[23], deed restriction or deeded encumbrance[24] for the project area to be maintained as grassland (other than the easement that is enacted for the project); and,
2. There must be no zoning, permitting, ownership, or other legal obstacle to the conversion of the project area to cropland; and,
3. There must be no federal, state, or local regulation that would prohibit ongoing management of the project area as cropland.

[23] An agreement that can be enforced specifically, that is, where a party to the agreement (who is not participating as a "Grassland Owner") can prevent the physical breaking of the grassland, is considered a binding legal requirement.

[24] Unless all parties with a potential claim to soil carbon ownership participate in the project as Grassland Owners, per Section 3.2, any pre-existing encumbrance or restriction or any other recorded agreement, must expressly and unequivocally assign soil carbon ownership and control to the participating Grassland Owner(s) and/or expressly permit the participating Grassland Owner(s) and Project Developer(s) to undertake a soil carbon offset project on the project area. Any subsequent legally binding agreement must be made subordinate to the PIA (if applicable) and project-related conservation easement; the terms of a subsequent legally binding agreement must not be incompatible with an AGC project. See Sections 2.3.2 and 3.5.1 for more information on eligibility requirements regarding title recordings and encumbrances.

Parts 1 and 2 are assessed as of the project start date. Part 3 is assessed on an ongoing basis following the project start date. Voluntary agreements that can be rescinded, such as rental contracts, are not considered legal requirements. Temporary or emergency restrictions or regulations shall be assessed with regard to the legal requirement test so long as they constitute a legally binding mandate, as described in this section. If a temporary legal restriction would violate parts 1 and/or 2 above, the project may delay implementation until such time that the project may pass the legal requirement test. If a temporary legal restriction violates part 3 above, the project is ineligible to receive CRTs for the period of time during which the regulation is effective.

Habitat Conservation Plans (HCPs) and Safe Harbor Agreements (SHAs) are voluntary agreements that shield landowners from certain liabilities under the Endangered Species Act. Agreements of this nature that were approved more than 6 months prior to the project's start date are considered to be pre-existing legally binding agreements.[25] Agreements of this nature that are approved no more than 6 months prior to the project's start date and that satisfy Section 3.3.2.1 are not considered pre-existing legally binding agreements for the purpose of the legal requirement test.[26]

Any agreement that serves to generate credits or payments for ecosystem services derived from the land is subject to the eligibility requirements in Section 3.3.3.

Deeded encumbrances, such as conservation easements, may effectively control soil carbon. Deeded encumbrances that are enacted prior to the project start date are considered legally binding mandates for the purposes of the legal requirement test.

To satisfy the legal requirement test, the Project Owner must submit a signed Attestation of Voluntary Implementation form[27] as part of the verification activities for the initial verification (see Section 8). In addition, the project's Monitoring Plan (Section 6) must include procedures that the Project Owner follows to ascertain and demonstrate that the project at all times passes the legal requirement test.

3.3.2.1 Requirements for Concurrent Legally Binding Agreements

A Grassland Owner may concurrently enter into a legally binding agreement related to ecosystem services or protection on the project area, subject to Sections 3.3.2 for liability shielding agreements and/or Section 3.3.3 for ecosystem services or protection credit and payment stacking, under the following conditions. For liability shielding programs, i.e., HCPs and SHAs, an agreement is considered concurrently entered into if the legal agreement is approved no more than 6 months prior to the project start date. For credit and payment stacking programs, the agreement is considered concurrently entered into if the easement required by the ecosystem program serves both the ecosystem services program and the start date requirement of the GPP.

The Grassland Owner must ensure that the agreement, and/or the program under which the agreement is authorized, provides sufficiently clear language to demonstrate the legal

[25] While voluntary in nature, the penalties for terminating HCPs or SHAs are such that they are effectively legally-binding in the opinion of the Reserve. The allowance for agreements approved within 6 months of the project start date is based on the opinion that this represents a "concurrent" activity.
[26] While an agreement may not violate the legal requirement test, an easement or other deed restriction associated with the performance of that agreement may be a pre-existing legal requirement, and therefore disqualify certain portions, if not all, of the agreement area. See Section 3.3.2.1.
[27] Attestation forms are available at http://www.climateactionreserve.org/how/program/documents/.

additionality of the grassland project. Specifically, the agreement must make explicit that the Grassland Owner has the right to use the land covered by the agreement for the purposes of participating in a carbon offset market. The Reserve maintains the right to determine whether this issue is clear.

For agreements that require land to be put under perpetual conservation easement, the easement may also serve the requirements of a grassland project so long as the easement conforms to the requirements of Section 3.2. For agreements that require at least one perpetual conservation easement but allow for multiple subsequent easements, each easement should be evaluated individually. If any easement does not conform to Section 3.2, the portion of the land covered by that easement is ineligible as a project area.

3.3.3 Ecosystem Services Credit and Payment Stacking

When multiple ecosystem services credits or payments are sought for a single activity on a single piece of land, with some temporal overlap between the different credits or payments, it is referred to as "credit stacking" or "payment stacking," respectively (4). Under this protocol, credit stacking is defined as receiving both offset credits and other types of mitigation credits for the same activity on spatially overlapping areas (i.e., in the same acre). Mitigation credits are any instruments issued for the purpose of offsetting the environmental impacts of another entity, such as emissions of GHGs, removal of wetlands or discharge of pollutants into waterways, to name a few. Payment stacking is defined as issuing mitigation credits for a best management or conservation practice that is also funded by the government or other parties via grants, subsidies, payment, etc., on the same land.

Any type of conservation or ecosystem service payment or credit received for activities on the project area must be disclosed by the Project Owner to the verification body and the Reserve on an ongoing basis.

3.3.3.1 Credit Stacking

The Reserve identified two mitigation credit market opportunities that need to be assessed as part of the eligibility of a grassland project. These markets credit the same activity on the same acreage as a grassland project: permanently conserving grassland.

Endangered Species Habitat Credits

Endangered species habitat credits can be generated through habitat conservation banks. These conservation banks are authorized under Section 10 of the Endangered Species Act (ESA) to restore, create or otherwise protect endangered species habitat (5). Section 10 allows landowner-developers to perform certain actions that would otherwise result in an illegal taking of an endangered species or its habitat under Section 9 of the ESA, provided that they receive and comply with an incidental take permit from the U.S. Fish and Wildlife Services (FWS)[28]. The permit requires the landowner-developer to mitigate the negative impacts of the activity on the habitat, and may allow the landowner-developer to achieve this mitigation by purchasing – or generating – endangered species habitat credits from habitat conservation banks.

In order to establish a conservation bank and generate endangered species credits, FWS requires landowner-bankers to enter into a conservation bank agreement with the FWS and other relevant government agencies, and to record a perpetual conservation easement on the land covered by the conservation bank. A Grassland Owner can concurrently seek the

[28] U.S. Code Title 16, Chapter 35, §1539 - Exceptions (2009).

establishment of a conservation bank on the project area, but the Grassland Owner must ensure that both the conservation bank agreement and the perpetual easement provide sufficiently clear language to demonstrate the additionality of the grassland project, i.e., that potential revenues from the grassland project were considered at the time of the negotiation of both of these agreements.

The date of the easement recordation is subject to the start date requirements in Section 3.2 and the easement itself is subject to the easement requirements in Section 3.2. The conservation bank agreement is not considered to be a pre-existing legal requirement for the purposes of the legal requirement test so long as it satisfies Section 3.3.2.1.

Furthermore, FWS specifies that land used to establish conservation banks must not be previously designated for conservation purposes.[29] It is thus reasonable to assume that FWS would not approve a conservation bank and issue endangered species habitat credits to lands already engaged in a grassland project. However, it is ultimately the decision of FWS if such subsequent credit stacking is allowed.

Wetland Credits

Under the guidelines established for Section 404 of the Clean Water Act, developers may impact a wetland if those impacts are offset through the restoration, creation, enhancement or preservation of another wetland elsewhere. The Army Corps of Engineers-led Interagency Review Team (IRT)[30] may issue a Department of Army permit to authorize such actions subject to the creation of a wetland mitigation bank.[31] In some cases, wetland mitigation banks may include and credit the preservation of upland habitat that could be eligible under this protocol.

Similar to conservation banks, the acreage covered by mitigation banks is required to be protected in perpetuity.[32] A Grassland Owner can concurrently seek the establishment of a mitigation bank on the project area, but the Grassland Owner must ensure that both the mitigation bank agreement and the perpetual easement provide sufficiently clear language to demonstrate the additionality of the grassland project, i.e., that potential revenues from the grassland project were considered at the time of the negotiation of both of these agreements.

The date of the easement recordation is subject to the start date requirements in Section 3.2 and the easement itself is subject to the easement requirements in Section 3.2. The mitigation bank agreement is not considered to be a pre-existing legal requirement for the purposes of the legal requirement test so long as it satisfies Section 3.3.2.1.

Furthermore, federal law states that under no circumstances may the same credits be used to provide mitigation for more than one permitted activity but that, where appropriate, mitigation banks may be designed to holistically address requirements under multiple programs and authorities for the same activity.[33] It is then reasonable to assume that the IRT would not approve a mitigation bank and issue wetland credits to lands already engaged in a grassland

[29] *Ibid*.
[30] The Army Corps of Engineers is the chair; other members can be EPA, FWs, NRCS, NOAA and other federal, state, tribal, and local agency representatives.
[31] Code of Federal Regulations, Title 33, Part 332 (33 CFR 332).
[32] 33 CFR 332.3(h)(1)(v).
[33] 33 CFR 332.3 (j)(1)(ii).

project. However, it is ultimately the decision of the IRT if such subsequent credit stacking is allowed.

3.3.3.2 Payment Stacking

The Reserve has identified two general types of payments that support the grassland activities being credited under this protocol: “landscape-scale” payments and “enhancement” payments. The majority of these payments are available via programs implemented by the USDA NRCS. NRCS expressly allows the sale of environmental credits from enrolled lands,[34] but does not provide any further guidance on ensuring the additional environmental benefit of any payment for ecosystem service stacked with an NRCS payment.

Landscape-Scale Payments

Landscape-scale payments generally come from land conservation programs that prevent grazing and pasture land from being converted into cropland, used for urban development, or developed for other non-grazing uses. Participants in these programs voluntarily limit future development of their land through the use of long-term contracts or easements, and payments are generally made based on the value of the land being protected. Thus, these payments are incentivizing the same project activity as this protocol. Examples of landscape-scale payments include:

- NRCS Grasslands Reserve Program (2008 Farm Bill)
- NRCS Conservation Reserve Program (2008 Farm Bill)
- NRCS Farm and Ranch Lands Protection Program (2008 Farm Bill)
- NRCS Agricultural Conservation Easement Program (2014 Farm Bill)
- Conservation easement support offered by non-governmental organizations such as Ducks Unlimited, The Nature Conservancy and the Trust for Public Land (which are often themselves funded by government programs)

If a Grassland Owner concurrently seeks a landscape-scale payment on the project area, any easement or agreement on the project area is subject to the start date requirements in Section 3.2 and the legal requirement test in Section 3.3.2.

Furthermore, under the current rules of government funded programs the recordation of a new permanent conservation easement in order to initiate a grassland project would disqualify the lands from continued participation in any NRCS payment program.[35] Therefore, the Reserve does not expect lands participating in such programs will have the opportunity to stack payments once the project easement has been recorded, or subsequently stack such payments.

Because every available landscape-scale payment is not comprehensively addressed by the protocol at this time, the Project Owner must disclose any such payments to the verifier and the Reserve on an ongoing basis. The Reserve maintains the right to determine if payment stacking has occurred and whether or not it would impact project eligibility.

[34] Environmental Quality Incentives Program: 7 CFR §1466.36; CSP, 7 CFR §1470.37.

[35] Guidance on eligibility criteria for the CRP program, for both new enrollments and re-enrollments can be found here, respectively:
http://www.fsa.usda.gov/Internet/FSA_File/gs43factsheet.pdf
http://www.fsa.usda.gov/programs-and-services/conservation-programs/current-participants-general-public/index

Enhancement Payments

Enhancement payments provide financial assistance to landowners in order to implement discrete conservation practices that address natural resource concerns and deliver environmental benefits. For government-funded enhancement payments, participants sign short-term contracts and receive annual cost-share payments specific to the conservation practice they have implemented. Examples of relevant enhancement payments include:

- NRCS Environmental Quality Incentives Program (2014 Farm Bill)
- NRCS Conservation Stewardship Program (2014 Farm Bill)
- NRCS Continuous Conservation Reserve Program (2008 Farm Bill)
- NRCS Wildlife Habitat Incentive Program (2008 Farm Bill)

The practices that are compensated for by the programs above can only occur on land that is being maintained as grassland; however the payment contracts do not purport to pay for the preservation of the grassland, only its enhancement. Furthermore, the programs do not, in practice, sufficiently incentivize the preservation of grassland, much less compensate for the permanent conservation of grassland. Because of this, Grassland Owners may pursue enhancement payments without restriction.

Because every available enhancement payment is not comprehensively addressed by the protocol at this time, the Project Owner must still disclose any such payments to the verifier and the Reserve on an ongoing basis.

3.4 Project Crediting Period

The baseline for any grassland project registered under this protocol is valid for up to 50 years. This means that a registered grassland project is eligible to receive CRTs for GHG reductions quantified using this protocol, and verified by Reserve-approved verification bodies, for a period of up to 50 years following the project's start date. Certain strata may not generate baseline emissions for the full 50 years (as evidenced by a baseline emission factor for organic carbon loss equal to zero for a particular emission factor period), in which case the maximum crediting period is less than 50 years. In the case of project cooperatives, project crediting periods are tied to each individual grassland project within the cooperative and their respective start dates. Thus, unless all of the projects in the cooperative share the same start date, there is not a single crediting period applicable to the entire cooperative.

Projects may elect to end their crediting period at any time. Any CRTs that have been issued are subject to the permanence requirements described in Section 3.5. Any project that wishes to end its crediting period must notify the Reserve prior to the next monitoring or reporting deadline, as determined in Section 7.4. If a project chooses to end its crediting period, no future emission reductions may be reported. If a project would like to forgo credits for a period of time in order to delay verification, this is considered a Zero-Credit Reporting Period.[36]

3.5 Requirements for Permanence

To validly offset GHG emissions, the reversible emission reductions credited under this protocol must be permanent. An emission reduction is considered reversible if it is related to carbon which remains stored in a carbon pool, such as soil organic carbon. An example of a non-reversible emission reduction on a grassland project would be the avoided N_2O emissions

[36] See the Reserve Program Manual, available at: http://www.climateactionreserve.org/how/program/program-manual/.

related to baseline fertilizer use. For the purposes of this protocol, an emission reduction is considered "permanent" if the quantity of carbon associated with that reduction is stored for at least 100 years following the issuance of a credit for that reduction. Once an emission reduction is considered permanent, it is no longer considered reversible. For example, if CRTs are issued to a grassland project in year 24 following its start date, soil carbon in the project area must be maintained through at least year 124. To meet this requirement, Project Owners must monitor and verify a grassland project for a minimum period of 100 years following the issuance of any CRT for GHG reductions achieved by the project, unless the project is terminated. Failure to maintain ongoing monitoring and verification may result in the automatic termination of the project. Note that this means that monitoring and verification for a project must continue even after the end of the project's crediting period. The period of time after the project crediting period has ended and before the minimum time commitment has been met is referred to as the "permanence period".

If carbon is released before the end of the 100-year period after a CRT is issued, the release is termed a "reversal". A reversal occurs if stored carbon is actually released through a disturbance of the project area, or is deemed to be released through termination of the project or a portion of the project. Reversals may impact only a portion of the project area or the entire project area.

This protocol distinguishes between two categories of reversals, avoidable and unavoidable, and specifies separate remedies for each. Many biological and non-biological agents, both natural and human-induced, can cause reversals. Some of these agents cannot completely be controlled (and are therefore "unavoidable"), such as natural agents like fire, insects, and wind. This protocol also takes into consideration the extent to which a Project Owner has contributed towards the reversal through negligence, gross negligence or willful intent. Thus reversals caused by biological agents, where the Project Owner has not contributed to the reversal through negligence, gross negligence or willful intent, are considered unavoidable.

An avoidable reversal occurs if:

1. The Project Owner voluntarily terminates the project prior to the end of the 100-year time commitment. A Project Owner may voluntarily terminate the entire project, or a portion of the project area. If only a portion is terminated, then the reversal is considered to affect only the terminated area.
2. There is a breach of certain terms described within the Project Implementation Agreement (see Section 3.5.2, below). Such a breach results in the entire project being automatically terminated.
3. The Project Owner prematurely ceases ongoing monitoring and verification activities. Monitoring, reporting, and verification requirements are described in Sections 6, 7, and 8. Cessation of monitoring and verification results in the entire project being automatically terminated.
4. Any activity occurs on the project area that leads to a significant disruption of soil carbon. Examples include, but are not limited to, cropping activities (conversion to cropland), eminent domain, mining or drilling activities, or installation of wind turbines. In most cases, such disturbances would not constitute a reversal on the entire project area.
5. A natural disturbance occurs to the soil carbon in the project area, and the Reserve determines that the disturbance is attributable to the Grassland Owner's or Project Owner's negligence, gross negligence, or intentional mismanagement of the project area as grassland.

Avoidable reversals must be communicated to the Reserve and compensated for by the Project Owner, as prescribed in Section 5.4.

To ensure that the permanence obligations are guaranteed for the duration of the minimum time commitment, projects are required to employ a Qualified Conservation Easement (QCE) (Section 3.5.1) and a Project Implementation Agreement (Section 3.5.2).

For the purposes of this protocol, both QCEs and the PIA must be effective for 100 years following the issuance of CRTs. However, it may be the case that state law for the project area places limitations on the term length for contracts of this sort. For example, in North Dakota, property easements and restrictions are subject to a maximum limit of 99 years.[37] CRTs will only be issued for periods of time for which the required easement(s) are effective for at least 100 years following the year in which the emission reduction was generated. For projects where length of property restrictions is limited by state law, CRTs issued for any given reporting period shall be held by the Reserve for a period of time based on the contract length. These CRTs shall be released following a subsequent renewal of the property restrictions such that the restrictions are effective through a date that is at least 100 years after the end of the relevant reporting period.

For example, if a verification period covers two 12-month reporting periods, and a 99-year easement is recorded at the end of the verification period, CRTs will only be issued for the first reporting period. CRTs for the second reporting period shall be withheld until such time as the easement is rerecorded, thus ensuring permanence for at least 100 years from the end of the second reporting period.

3.5.1 Qualified Conservation Easements

A conservation easement is required for all grassland projects except for those where ownership of the project area is transferred to the Federal Government. The area bound by the conservation easement does not need to match the project area. However, the entire project area must be included in the area of the conservation easement. A Qualified Conservation Easement (QCE) is one whose terms prevent the conversion of the project area from grassland to another land use, such that avoidable reversals are sufficiently precluded as long as the easement is enforced. For example, whereas a basic conservation easement may only restrict the subdivision and/or development of the project area, a QCE would also restrict activities such as plowing and farming, which could release carbon stored in the soil. The QCE may allow for other activities, such as road or building construction, on the land bound by the easement. However, insofar as these activities would result in a land use other than grassland, the areas where they are allowed should be specified in the QCE and subsequently excluded from the project area in order to avoid the occurrence of a reversal due to such activities. Additionally, the QCE may make reference to the carbon project and simply specify that any non-grassland land use must occur outside of the specified project area. The language of the QCE should be sufficiently clear to reasonably prevent cultivation on the entire project area.

There are additional provisions for project conservation easements that the Reserve strongly encourages, but does not require. For enhanced transparency and legal clarity, the conservation easement should explicitly 1) refer to, and incorporate by reference, the terms and conditions of the PIA and the GHG reduction rights agreement, thereby binding both the grantor

[37] North Dakota Century Code §47-05-02.1, *Requirements of easements, servitudes, or nonappurtenant restrictions on the use of real property*. Accessible at: http://www.legis.nd.gov/cencode/t47.html.

and grantee – as well as their subsequent assignees – to the terms of the agreements for the full duration of the grassland project's minimum time commitment, as defined in Section 3.5 of this protocol; and 2) make all future encumbrances and deeds subject to the PIA.[38] It is also recommended that the QCE incorporate and require environmental best management practices for rangeland management (Section 2.4).

3.5.2 Project Implementation Agreement

Permanence obligations must be guaranteed through a legal agreement that obligates the Project Owner to conduct monitoring activities on the project area for the required period of 100 years following CRT issuance, and to compensate for avoidable reversals that occur during that period. For grassland projects this agreement is known as the Project Implementation Agreement.[39] Requirements for monitoring and reporting activities during the permanence period are detailed in Section 7.5.

The PIA is an agreement between the Reserve and a Project Owner setting forth: (i) the Project Owner's obligation (and the obligation of its successors and assigns) to comply with the Grassland Project Protocol, and (ii) the rights and remedies of the Reserve in the event of any failure of the Project Owner to comply with its obligations. The PIA must be signed by the Project Owner before a project can be registered with the Reserve. The PIA is executed and submitted after the Reserve has reviewed the verification documents and is otherwise ready to register the project. It is not possible to terminate the PIA for only a portion of the project area; however an amended PIA may be executed that reflects a change to the project area as provided for by the exceptions to the minimum time commitment at the beginning of this section. The PIA is also amended at each subsequent verification in order to extend the term of applicability.

There are two types of PIAs available to a grassland Project Owner:

Contract PIA

A Contract PIA is a contract between the Project Owner and Reserve whereby the Project Owner agrees to the requirements of the protocol, including but not limited to monitoring, verification, and compensating for reversals. The PIA does not restrict the transferability of the specific CRTs issued, but does hold the Project Owner to the compensation requirements of Section 5.4. By the terms of the PIA, the contract is satisfied upon the Project Owner's full performance of the requirements of this protocol (i.e., monitoring and verifying permanence for 100 years following CRT issuance). The PIA is executed at the completion of the initial project verification, and then amended at the completion of each subsequent verification (prior to or at the time of CRT issuance). The Contract PIA is not a public document.

Recorded PIA

In the case where the Project Owner is the Grassland Owner, or where the Grassland Owner is willing to record the PIA on the deed to the property, the Project Owner may employ a Recorded PIA. This is a contract between the Project Owner and the Reserve that is recorded on the deed to the property and binds the Project Owner and Grassland Owner to the terms of the protocol. This version of the PIA does not grant the Reserve a

[38] The approach to subordination of the PIA will impact the project's contribution to the risk buffer pool, as described in Section 5.4.3.

[39] The template PIA is available on the GPP webpage: http://www.climateactionreserve.org/how/protocols/grassland/.

security interest, but rather grants the Reserve the ability to enforce the protocol requirements on the project area. The Recorded PIA is publicly available from the records office of the county in which the project is located.

3.6 Regulatory Compliance

As a final eligibility requirement, Project Owners must attest that project activities do not cause material violations of applicable laws (e.g., air, water quality, safety, etc.). To satisfy this requirement, Project Owners must submit a signed Attestation of Regulatory Compliance form[40] prior to the commencement of verification activities each time the project is verified. Project Owners are also required to disclose in writing to the verifier any and all instances of legal violations – material or otherwise – caused by the project activities. Where a temporary or emergency restriction or regulation is in force during the reporting period, it shall be included in the assessment of the project's regulatory compliance.

A violation should be considered to be "caused" by project activities if it can be reasonably argued that the violation would not have occurred in the absence of the project activities. If there is any question of causality, the Project Owner shall disclose the violation to the verifier.

If a verifier finds that project activities have caused a material violation, then CRTs will not be issued for GHG reductions that occurred during the period(s) when the violation occurred. Individual violations due to administrative or reporting issues, or due to "acts of nature," are not considered material and do not affect CRT crediting. However, recurrent administrative or reporting violations directly related to project activities may affect crediting, especially if related to negligence or intent on the part of the Project Owner or Grassland Owner. Verifiers must determine if recurrent violations rise to the level of materiality. If the verifier is unable to assess the materiality of the violation, then the verifier shall consult with the Reserve.

3.7 Ecosystem Health

Grassland project areas, regardless of location or management, are subject to forces that could degrade the grassland ecosystem and potentially cause the land to transition to a different landscape type, even in the absence of a single disturbance event. Such degradation or landscape transition not only has the potential to negatively impact the belowground carbon stocks (thus jeopardizing the integrity of the project quantification), but may also lead to eventual conversion of the project area to a land use other than grassland (e.g., dense shrubland, forest, bare soil, etc.). Project activities such as livestock grazing or recreation could also lead to impaired rangeland health, if not properly managed. Projects that are located adjacent to land that has already been converted to cropland or development may also be subject to a higher risk of rangeland health impairment due to encroachment of invasive species or increased grazing/foraging by wild animals whose habitat has been constrained by land conversion. The Reserve does not seek to prescribe specific land management activities. Rather, the intent of this section is to encourage thoughtful and proactive land management to maintain and/or improve rangeland health.

In order to protect against long term degradation of the project area, periodic assessments of rangeland health[41] must be conducted according to the guidance contained in Section 6.4. For any metrics that are determined to display "moderate" departure from the reference condition,

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[40] Attestation forms are available at http://www.climateactionreserve.org/how/program/documents/.

[41] Additional details regarding the U.S. Federal Government's multi-agency program for assessing Rangeland Health can be found at: http://jornada.nmsu.edu/monit-assess/manuals/assessment (accessed 10/14/16).

the Project Owner must document how the land management will be adapted to address these deficiencies. If the assessment determines that the project area exhibits greater than “moderate” departure from the defined reference condition for any metric, the Project Owner must not only show a plan for management adaptation, but must also show improvement in that metric at the subsequent rangeland health assessment.

If projects that are required to improve rangeland health fail to do so at the subsequent assessment, the Reserve will determine whether the degradation was avoidable or unavoidable. Avoidable degradation could lead to ineligibility for the current reporting period, resulting in no CRTs being issued for that period. If the continued degradation is determined to be unavoidable, the project may still receive CRTs for the reporting period, but must abide by the requirements of the previous paragraph to implement new management approaches to improve rangeland health.

In cases where there is a rangeland health assessment showing greater than moderate departure from the reference condition for one or more metrics, the Reserve will consult with rangeland health experts to determine whether the degradation is sufficiently significant to warrant the determination that a reversal has occurred. In cases where is the Reserve determines that a reversal has occurred, the requirements of Section 5.4 regarding avoidable and unavoidable reversals shall apply.

4 The GHG Assessment Boundary

The GHG Assessment Boundary delineates the GHG sources, sinks, and reservoirs (SSRs) that must be assessed in order to determine the net change in emissions caused by an avoided conversion of grasslands project.[42] The GHG Assessment Boundary encompasses all of the GHG SSRs that may be significantly affected by project activities, including biological CO_2 emissions and soil carbon sinks and sources of N_2O.

Figure 4.1 illustrates all relevant GHG SSRs associated with grassland project activities and delineates the GHG Assessment Boundary.

Table 4.1 provides greater detail on each SSR and justification for the inclusion or exclusion of certain SSRs and gases from the GHG Assessment Boundary. The SSRs that are marked with "(R)" represent those for which baseline emissions are reversible, and thus subject to the requirements for permanence in Section 3.5.

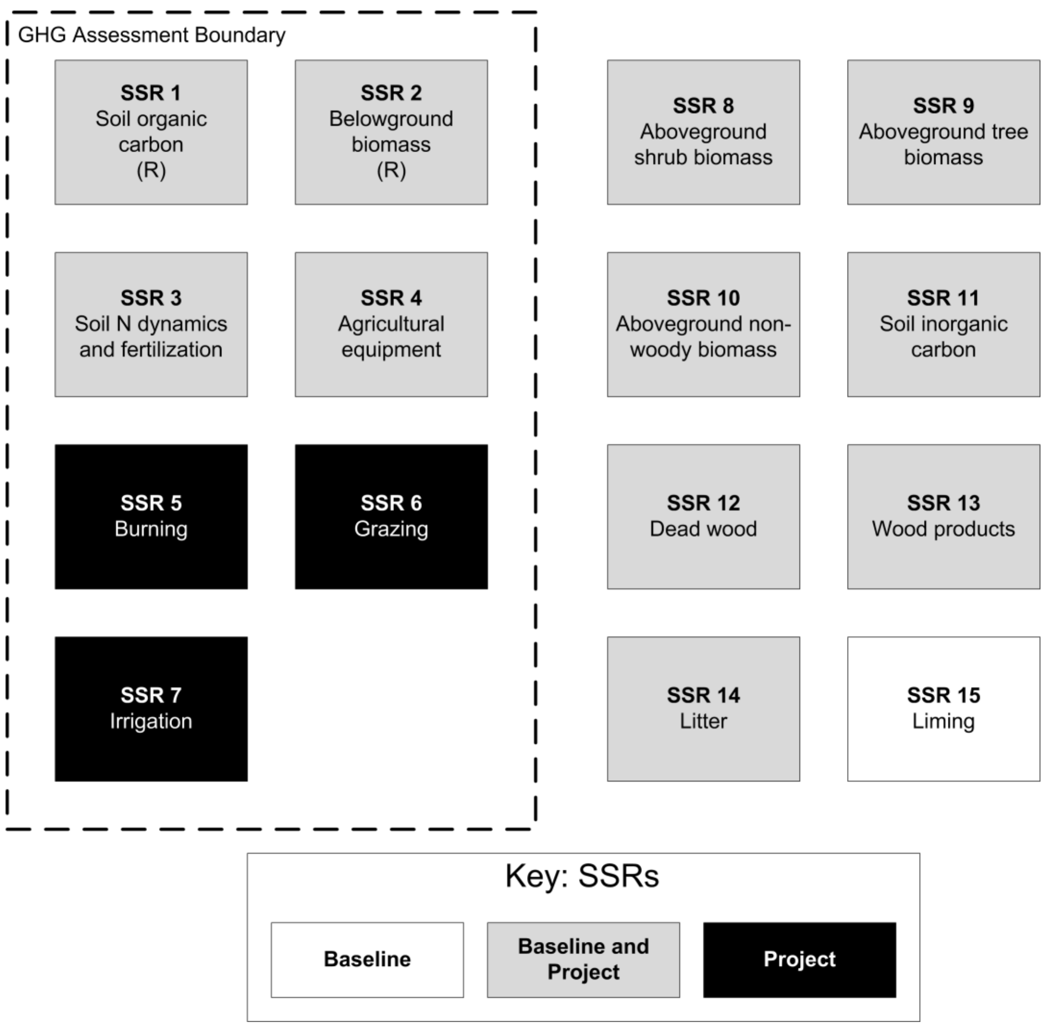

Figure 4.1. General Illustration of the GHG Assessment Boundary

[42] The definition and assessment of sources, sinks, and reservoirs is consistent with ISO 14064-2 guidance.

Table 4.1. Description of All Sources, Sinks, and Reservoirs

SSR	Source Description	Gas	Included (I), Optional (O), or Excluded (E)	Quantification Method	Justification/Explanation
1	Soil organic carbon	CO_2	I	Default emission factor modeled using DAYCENT	Emissions from the loss of soil organic carbon are a primary effect and major emission source in the baseline. Reversible.
2	Belowground biomass	CO_2	I	Default factor modeled using DAYCENT	Emissions from the loss of below-ground biomass are a primary effect and major emission source in the baseline. Reversible.
3	Soil nitrogen dynamics and fertilization	N_2O	I	**Baseline:** Default emission factors modeled using DAYCENT **Project:** Calculated based on monitored data	Direct and indirect N_2O emissions from conversion activities, soil processes and fertilization can be significant in the baseline. Direct and indirect N_2O emissions from fertilization can be significant in the project scenario, if applicable.
4	Agricultural equipment from site preparation and ongoing operations	CO_2	I*	**Baseline:** Default emission factor **Project:** Calculated based on monitored data	Fossil fuel emissions from equipment used for conversion site preparation and ongoing field operations (tillage, fertilization, etc.) may be significant in the baseline. * Associated emission reductions excluded in jurisdictions where these emissions are subject to a binding cap (e.g., California). Fossil fuel and electricity emissions from equipment used for grassland management may be significant in the project scenario.
		CH_4	E	N/A	Excluded, as this emission source is assumed to be very small. The exclusion is conservative.
		N_2O	E	N/A	Excluded, as this emission source is assumed to be very small. The exclusion is conservative.
5	Burning	CO_2	E	N/A	CO_2 emissions due to grass biomass burning are considered biogenic and thus are excluded from the project boundary.

SSR	Source Description	Gas	Included (I), Optional (O), or Excluded (E)	Quantification Method	Justification/Explanation
		CH_4	I	Calculated based on monitored data	When grass biomass is burned, a portion of the carbon is released as CH_4. Depending on the area burned, this could be a significant source of project emissions.
		N_2O	I	Calculated based on monitored data	When grass biomass is burned, a portion of the carbon is released as N_2O. Depending on the area burned, this could be a significant source of project emissions.
6	Grazing	CO_2	E	N/A	Excluded, as this is not a significant source of emissions. Additionally, any CO_2 emissions from grazing would be considered biogenic.
		CH_4	I	Calculated based on monitored data	Grazing livestock in the project scenario produces potentially significant quantities of CH_4 through the decomposition of manure, as well as enteric fermentation.
		N_2O	I	Calculated based on monitored data	Grazing livestock in the project scenario produces potentially significant quantities of N_2O through the decomposition of manure.
7	Irrigation	CO_2	I	Calculated based on monitored data	Emissions from equipment used for grassland management may be significant in the project scenario.
		CH_4	E	N/A	No significant CH_4 emissions related to irrigation of the project area are expected.
		N_2O	I	Calculated based on monitored data	Indirect N_2O emissions from irrigation can be significant in the project scenario, where livestock grazing and/or fertilizer application occurs.
8	Aboveground shrub biomass	CO_2	E	N/A	Emissions from the loss of above-ground shrub biomass can be a significant emission source in the baseline for certain projects. Exclusion is conservative.

SSR	Source Description	Gas	Included (I), Optional (O), or Excluded (E)	Quantification Method	Justification/Explanation
9	Aboveground tree biomass	CO_2	E	N/A	Trees may hold a significant amount of biomass, but the fate of that carbon after conversion is uncertain, depending upon the volume of wood, the species, and the accessibility of mills. This protocol conservatively excludes tree biomass from the baseline emissions calculations.
10	Aboveground non-woody biomass	CO_2	E	N/A	Excluded, as the permanent pool is assumed to be very small, despite seasonal fluxes. The exclusion is conservative.
11	Soil inorganic carbon	CO_2	E	N/A	Excluded, as this source is not included in the baseline modeling. The exclusion is conservative.
12	Dead wood	CO_2	E	N/A	Excluded, as this emission source is assumed to be very small. The exclusion is conservative.
13	Wood products	CO_2	E	N/A	Excluded, as this emission source is assumed to be very small. The exclusion is conservative.
14	Litter	CO_2	E	N/A	Excluded, as this emission source is assumed to be very small. The exclusion is conservative.
15	Liming	CO_2	E	N/A	Excluded, as the direction and magnitude of this emission source is uncertain. Current IPCC emission factors treat liming as an emission source, whereas current USDA quantification methodologies treat it as a net sink (6) (7).

5 Quantifying GHG Emission Reductions

GHG emission reductions from an avoided grassland conversion project are quantified by comparing actual project emissions to the calculated baseline emissions. Baseline emissions are an estimate of the GHG emissions from sources within the GHG Assessment Boundary (see Section 4) that would have occurred in the absence of the project. In the case of grassland projects, the baseline emissions include the loss of belowground organic carbon through conversion to cropland, as well as the GHG emissions from crop production. Project emissions are actual GHG emissions that occur at sources within the GHG Assessment Boundary. Project emissions include GHG emissions from grassland maintenance and grazing, as well as any leakage of baseline conversion activities. Project emissions must be subtracted from the baseline emissions to quantify the project's total net GHG emission reductions (Equation 5.1).

Quantification of baseline emissions is done through the use of default emission factors developed through a probabilistic composite modeling approach. This approach greatly simplifies the quantification and monitoring of grassland projects, as compared to an approach based on site-specific sampling and modeling. Additional discussion of this approach can be found in Appendix B.

Timelines for quantifying and reporting GHG emission reductions are detailed in Section 7.4. Project Owners may choose to quantify and verify GHG emission reductions on a more frequent basis if they desire. The length of time over which GHG emission reductions are periodically quantified is called the "reporting period." The length of time over which GHG emission reductions are verified is called the "verification period." Under this protocol, a verification period may cover multiple reporting periods (see Section 7.4).

As of this writing, the Reserve relies on values for global warming potential (GWP) of non-CO_2 GHGs published in the IPCC Second Assessment Report: Climate Change 1995.[43] The values relevant for this protocol are provided in Table 5.1, below. These values are to be used for all grassland projects unless and until the Reserve issues written guidance to the contrary.

Table 5.1. 100-year Global Warming Potential for Non-CO_2 GHGs

Non-CO_2 GHG	100-Year GWP (CO_2e)
Methane (CH_4)	21
Nitrous Oxide (N_2O)	310

For project cooperatives, the quantification of emission reductions is carried out separately for each individual project. The cooperative structure does not change the quantification methodology contained within this section. To report the total results for the cooperative, the Cooperative Developer shall sum the results of Equation 5.1 for each project in the cooperative. However, it should be noted that CRTs are serialized and issued to individual projects, rather than the cooperative.

[43] Available here: https://www.ipcc.ch/publications_and_data/publications_and_data_reports.shtml.

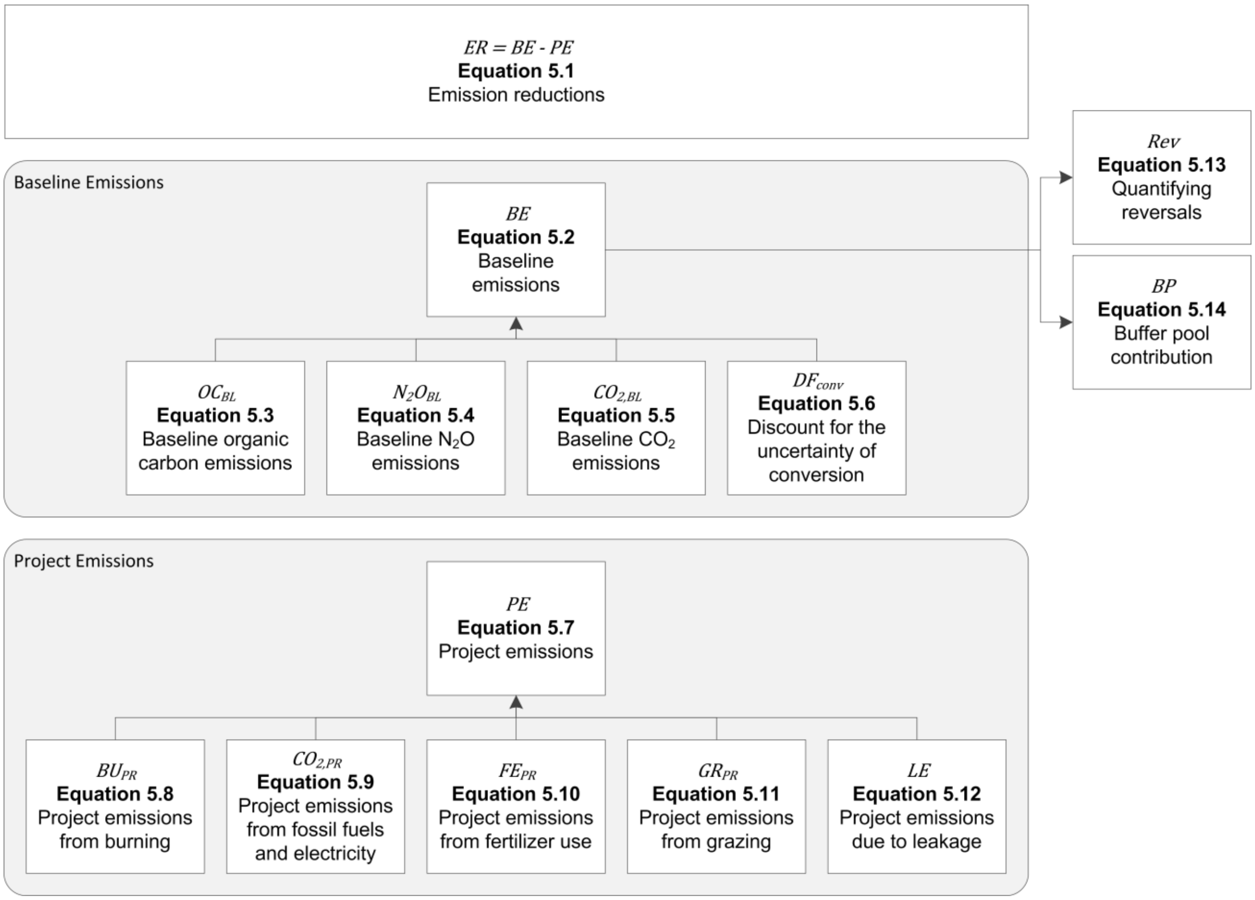

Figure 5.1. Organization of Quantification for Grassland Projects

Equation 5.1. GHG Emission Reductions

$$\boldsymbol{ER = BE - PE}$$

Where, <u>Units</u>

ER	=	Total emission reductions for the reporting period	tCO_2e
BE	=	Total baseline emissions for the reporting period, from all SSRs in the GHG Assessment Boundary (as calculated in Section 5.1)	tCO_2e
PE	=	Total project emissions for the reporting period, from all SSRs in the GHG Assessment Boundary (as calculated in Section 5.3)	tCO_2e

5.1 Stratification

For the purposes of this protocol, the U.S. has been stratified in order to enable the development of baseline and project emissions estimates that correspond to local soil conditions, climatic conditions, starting condition, and agricultural practices. A stratum represents a unique combination of these variables. All baseline and project modeling has been performed at the stratum level, enabling the resulting emissions estimates to represent relatively fine distinctions in the primary drivers of variation in emissions. In total, this protocol establishes emissions estimates for 1,002 total strata within the U.S. By stratifying the country in this manner, the emissions estimates used in this protocol provide greater local accuracy and representation than would emission estimates generated at a national scale or with fewer variables. These variables act as filters that bring greater specificity to the emissions estimates by more precisely estimating the conditions of the project. Land is first broken down by climate and geography, then further delineated by the major soil type and texture, and finally evaluated based on the previous land use.

For large projects, the project area may cover more than one stratum. In these instances, the project itself shall be divided up on an acreage basis into all appropriate strata. Instructions for identifying and calculating acreage in each stratum are provided in Section 5.1.4. All calculations shall be performed at the stratum level and summed to the project level where indicated.

The following variables are used to stratify the U.S., and shall be used to determine the appropriate stratum for a project or project area:

- Geography and associated climate
- Soil texture
- Previous land use

Each project shall be evaluated on the basis of each of these variables to determine its appropriate stratum, or strata, should its area contain multiple strata. The following sections provide guidance on determining the appropriate stratum for any parcel or portion of the project area.

5.1.1 Geography and Associated Climate

The first level of stratification used in this protocol delineates land based on its geography and associated climate, due to these factors' important influence over carbon pools and sources in both natural and managed ecosystems (6). Regional climate and geographic conditions are determined through the use of Major Land Resource Area designations, as defined by the USDA NRCS (9). These designations are used for a variety of policy and planning decisions, as they represent information about land suitability for farming and other purposes. As such, they constitute a land area that has similar physical and climatic characteristics. In total, there are approximately 280 MLRAs in the U.S. However, some of these MLRAs contain very little cropland or grassland feasible for conversion. Appendix B provides an overview of the methodology used to screen out certain MLRAs based on the absence of significant areas of grassland or cropland, and constraints on data availability and modeling confidence.

The USDA NRCS makes available tools for the geographic identification of MLRAs.[44]

5.1.2 Soil Texture

Soil texture has a significant impact on land productivity and carbon dynamics through influences on soil fertility and water balance and on soil organic matter stabilization processes (8). Accordingly, the second level of stratification requires differentiating by soil texture. While successively finer delineations of soil type and texture would yield greater precision, this protocol limits the stratification of soils into three major classes of surface soil texture as defined by USDA. These are:

- Coarse

[44] MLRA geographic data are available at: http://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/survey/geo/?cid=nrcs142p2_053624.

- Medium
- Fine

Table 5.3 explains how these three categories can be mapped to the various soil surface textures as they are listed in the soil database.

5.1.3 Previous Land Use

Initial carbon pools at project commencement are significantly influenced by previous land uses. Additionally, soil quality at project initiation influences nutrient inputs and farming practices in the baseline scenario. Because this protocol allows for the avoided conversion of grasslands with somewhat varied histories, the third level of stratification requires grasslands to be delimited by the duration of time the project area has been in a grassland state. This protocol defines the following two categories for grasslands:

- Greater than 10, but less than 30 years continuous grassland
- Greater than 30 years continuous, long-term permanent grassland

Per Section 3.1, all lands enrolled under this protocol must have been in a documented grassland or pastureland state for at least 10 years prior to project commencement. This requirement is necessary to ensure the validity of the baseline soil carbon emission factors. Areas that have exceeded 30 years of pre-project grassland cover are classified in a different stratum.

The Project Owner must document that the project site meets the definition of grassland as of the project start date. This may be done through a site visit by the verifier, or through other sources of evidence. Project Owners can use a wide variety of types of evidence, subject to review by the verifier. Evidence must cover every year that the land is asserted to have been grassland. It is easier for a verifier to confirm that the project area was in grasslands when the Project Owner provides evidence that is as specific and objective as possible. Table 5.2 below contains examples of the two categories of evidence (categories A and B) that may be employed to document land use of the project area for a given period of time. Category A evidence is independently sufficient for documenting land use for the relevant time period. Category B evidence may be used, but additional evidence (of either category) must be provided for the same period of time.

For example, if a Project Owner can provide time-stamped aerial photos of the project area for every year of land use that must be documented, that is considered sufficient. If a Project Owner provides satellite data indicating grassland as the land cover on the project area for a given year, at least one additional form of documentation (such as a contract or an affidavit) is required for corroboration. Evidence cannot be corroborated by other evidence of the same type (e.g., satellite evidence cannot be corroborated by other satellite evidence). All land use evidence shall be subject to review and approval by the verifier.

Table 5.2. Evidence Options for Land Use Justification

Category A: Evidence that is independently sufficient	Category B: Evidence that must be corroborated
▪ Site visit by the verifier (applies only to the relevant reporting period) ▪ Time-referenced photos of the project area taken during the relevant year(s) (applies to the areas that can reasonably be assessed with these photos) ▪ Time-referenced aerial photos taken during the relevant year(s)	▪ Satellite data products, such as the Cropland Data Layer (CDL)[45], National Land Cover Database,[46] or MODIS Enhanced Vegetative Index[47] ▪ Contract(s) covering the relevant year(s) whose terms would require that the project area be grassland, but that would not cause the project to fail the legal requirement test (e.g., grazing leases or haying contracts) ▪ Tax records that indicate the land use during the relevant year(s) ▪ Notarized affidavit(s) from unrelated and unaffiliated parties attesting to the land use in the relevant year(s) ▪ Notarized affidavit from the Grassland Owner(s) attesting to the land use in the relevant year(s) ▪ Other official records submitted to or generated by a government agency that would indicate the land use or management during the relevant year(s)

Table 5.2 is not meant to be comprehensive. The Project Owner may employ alternative approaches to monitoring land use on the project area, subject to review by the verifier. The evidence provided to satisfy this requirement must be sufficient to provide reasonable assurance as to the nature of the land use during the relevant time period. Forms of evidence not listed under Category A shall be assumed to belong to Category B unless otherwise determined, in writing, by the Reserve. The Reserve has developed a companion document to this protocol, the Grassland Project Handbook, that provides further detail and discussion of the various options for satisfying the requirements of this section.[48]

5.1.4 Stratum Identification and Measurement

In total, this protocol stratifies the U.S. into 1,674 unique strata based on the three variables previously discussed (although emission factors were only able to be generated for 1,002 strata; see Appendix B for further details). Box 5.1 describes the method for naming each individual stratum. These names are then used in the companion tables for default parameters provided for each stratum.[49]

[45] The Cropland Data Layer is a free remote sensing product developed and provided by the USDA National Agricultural Statistics Service. The data are available online at: http://nassgeodata.gmu.edu/CropScape/.
[46] The NLCD is a free remote sensing product provided by the Multi-Resolution Land Characteristics Consortium. The data are released every 5 years and is available online at: http://www.mrlc.gov/.
[47] MODIS data are provided by NASA and the USGS. Information regarding MOD13Q1 (the 16-day 250m global vegetation indices) is online at: https://lpdaac.usgs.gov/products/modis_products_table/mod13q1.
[48] The Grassland Project Handbook is available for download from the Reserve website at: http://www.climateactionreserve.org/how/protocols/grassland/. This handbook will be updated periodically.
[49] Certain parameters required for project eligibility and quantification are contained in a separate document, *Grassland Project Parameters*, available at: http://www.climateactionreserve.org/how/protocols/grassland/.

Box 5.1. Stratum Naming Convention

Name format: **X_Y_Z**

Where,		Range of Values
X =	Numbered designation of the MLRA in which the stratum is found	1 – 278
Y =	Soil texture classification	coarse, medium, or fine
Z =	Minimum year threshold for the previous land use	10 or 30

EXAMPLES:

Stratum	MLRA	Soil Texture	Previous Land Use
1_Medium_10	1 - Northern Pacific Coast Range, Foothills, and Valleys	Medium	Greater than 10, but less than 30 years continuous grassland or pastureland
150A_Fine_30	150A - Gulf Coast Prairies	Fine	Greater than 30 years continuous, long-term permanent grassland or pastureland

Most quantification in this protocol is conducted at the stratum level. Equations require inputs in the form of total acreage within each stratum, and use of stratum-specific emission factors for various carbon pools and emissions sources. Project Owners must prepare a georeferenced map file that contains the entire project area, excluding any portion of the project parcels not legally permitted to be converted due to buffer restrictions[50] or other requirements.

Data from the Soil Survey Geographic Database must be used to identify the acres of the stratum for each soil texture class. It is recommended that Project Owners utilize the NRCS Web Soil Survey application (WSS),[51] which is a user-friendly tool for accessing data from SSURGO. SSURGO data are also available for direct download from the USDA NRCS Geospatial Data Gateway.[52] If an alternate source of data from the SSURGO is available, use of the WSS as described here is not required. At a minimum, Project Owners must be able to identify the acreage of each soil texture group based on the dominant condition[53] of each SSURGO map unit within the project area.

Through the WSS application, the user may locate the general area of the project and then draw a detailed polygon around the project area. This identifies the Area of Interest (AOI) for which the data are generated (it is preferable to use a previously-created shapefile to define the AOI, which ensures that the project boundaries are consistently defined). After identifying the correct AOI, select the “Soil Data Explorer” tab, then the “Soil Properties” subtab below it. Using the

[50] For example, a landowner may be subject to regulations which limit how close crops may be grown to property boundaries or watercourses, or may require the maintenance of forested areas around watercourses or as windbreaks. In these cases, those restrictions would be represented by creating buffers around those features and excluding the buffered region from the project area.
[51] This web application is available at: http://websoilsurvey.sc.egov.usda.gov/App/WebSoilSurvey.aspx.
[52] The USDA NRCS Geospatial Data Gateway may be accessed at: https://gdg.sc.egov.usda.gov/GDGOrder.aspx (last accessed 12/14/16).
[53] Soil map units are comprised of multiple components, which are not represented on the map. In order to assign a single value to the map unit based on the values of the components, some aggregation method must be selected. This protocol applies the “dominant condition” method, whereby the value which applies to the greatest total area of the map unit is used to represent the value of the entire map unit.

menu to the left, select "Soil Physical Properties" and then "Surface Texture." Within the options for Surface Texture, select the Aggregation Method as "Dominant Condition," then click "View Rating." This generates a table with the surface texture rating for each map unit within the AOI, identifying the acres for each. Then click "Printable Version" at the top right of the page to generate a PDF containing the AOI map and the table. This PDF aids with both stratification and verification. The texture ratings used in the soil data tables shall be aggregated into the three soil texture groups used in this protocol using the relationships described in Table 5.3.

Table 5.3. Soil Texture Categorization

SSURGO Texture Class	Grassland Protocol Texture Group
Sand	Coarse
Coarse sand	
Fine sand	
Very fine sand	
Loamy very fine sand	
Loamy fine sand	
Loamy sand	
Loamy coarse sand	
Coarse sandy loam	
Sandy loam	
Fine sandy loam	
Very fine sandy loam	
Loam	Medium
Silt loam	
Silt	
Sandy clay	Fine
Sandy clay loam	
Silty clay loam	
Clay loam	
Silty clay	
Clay	

5.2 Quantifying Baseline Emissions

Total baseline emissions for the reporting period are estimated by calculating and summing the emissions from all relevant baseline SSRs that are included in the GHG Assessment Boundary (as indicated in Table 4.1).

The baseline emission equations rely on emission factors that model the emissions of a full year. If this quantification methodology is being applied to a reporting period of less than one full year, Project Owners must refer to Box 5.2 in order to correctly pro-rate the annual baseline emission factors. Baseline emission factors for soil organic carbon, nitrous oxide, and fossil fuel emissions are organized in ten year groups. Those ten years are counted as calendar years from the year of the project start date, inclusive. The emission factor group to be used for a given reporting period is based on the beginning date of that reporting period, and applies throughout the reporting period. For example, if the project start date is May 9, 2015, the "Year

1-10" emission factor group shall be used for all reporting periods that begin during the years 2015-2024. For reporting periods beginning during 2025-2034, the "Year 11-20" emission factor group shall be applied.

Equation 5.2. Baseline Emissions

$$BE = \left[\left(OC_{BL} + N_2O_{BL} + CO_{2,BL}\right) \times (1 - DF_{\sigma})\right] \times (1 - DF_{conv}) \times Pro$$

Where,

			Units
BE	=	Total baseline emissions for the reporting period, rounded down to the nearest whole number	tCO_2e
OC_{BL}	=	Baseline emissions due to loss of organic carbon in soil and biomass (Equation 5.3)	tCO_2e
N_2O_{BL}	=	Baseline emissions of nitrous oxide (Equation 5.4)	tCO_2e
$CO_{2,BL}$	=	Baseline CO_2 emissions due to fossil fuel combustion (Equation 5.5)	tCO_2e
DF_{conv}	=	Discount factor for the uncertainty of baseline conversion (Equation 5.6)	%
DF_{σ}	=	Discount factor for the uncertainty of modeling future management practices and climatic conditions[54]	%
Pro	=	Pro-rating factor for reporting periods of less than one year (see Box 5.2)	%

Box 5.2. Pro-Rating for Reporting Periods of Less than One Year

Projects may report GHG reductions more frequently than on an annual basis. If a project reports on a sub-annual basis, then annual emission factors and quantities used in this section must be prorated. The following equation shall be used to determine the pro-rating factor for a sub-annual reporting period:

$$Pro = \frac{rd}{365.25}$$

Where,

			Units
Pro	=	Pro-rating factor	%
rd	=	Number of reporting days in the sub-annual reporting period (i.e., days for which the project is claiming credit for emission reductions)	Days
365.25	=	Average number of days in a calendar year	Days

5.2.1 Baseline Organic Carbon Emissions

The baseline assumption for grassland projects is that the project area would be converted to cropland absent the project activities. When grassland is converted to cropland, carbon emissions occur through the loss of stored soil organic carbon over time. There is an immediate loss of soil carbon when the soil is tilled (9), followed by potentially decades of loss until a new equilibrium is reached. Determining the exact nature of the converted land use (crop rotation, tillage practices, fertilization, ongoing management) is complex, uncertain, and subjective. The Reserve has adopted a modeled, composite approach to determining organic carbon emissions from the baseline scenario for grassland projects. Refer to Appendix B for the development of

[54] Certain parameters required for project eligibility and quantification are contained in a separate document, *Grassland Project Parameters*, available at: http://www.climateactionreserve.org/how/protocols/grassland/.

the emission factors used in this quantification and the companion tables for the baseline emission factors.

Equation 5.3. Baseline Organic Carbon Emissions from Soil and Belowground Biomass Loss

$$OC_{BL} = \sum_{S} (BEF_{OC,s} \times Area_s \div 1000)$$

Where, Units

OC_{BL}	=	Baseline quantity of organic carbon emissions from soil and belowground biomass	tCO_2e
S	=	Total number of strata	
S	=	Individual stratum	
$BEF_{OC,s}$	=	Annual baseline emission factor for organic carbon in stratum *s* (refer to companion tables,[55] selecting the appropriate stratum and time category)	kg CO_2e/ac/yr
$Area_s$	=	Area of project in stratum *s*	acres
1000	=	Conversion factor	kg/t

5.2.2 Baseline N_2O Emissions

The use of fertilizer for crop cultivation results in emissions of nitrogen in the form of N_2O, which is a potent GHG.[56] Using emission factors developed with the composite modeling approach described in Appendix B, baseline emissions of N_2O are estimated for each stratum.

Equation 5.4. Baseline N_2O Emissions

$$N_2O_{BL} = \sum_{s}^{S} (BEF_{N_2O,s} \times Area_s \times GWP_{N_2O} \div 1000)$$

Where, Units

N_2O_{BL}	=	Baseline emissions of N_2O	tCO_2e
$BEF_{N2O,s}$	=	Annual baseline emission factor for N_2O emissions in stratum *s* (refer to companion tables,[55] selecting the appropriate stratum and time category)	kg N_2O/ac/yr
$Area_s$	=	Area of the project in stratum *s*	acres
GWP_{N2O}	=	100-year global warming potential of N_2O (refer to Table 5.1).	CO_2e/N_2O
1000	=	Conversion factor	kg/t

5.2.3 Baseline CO_2 Emissions from Fossil Fuels

The conversion of grassland to cropland, as well as the ongoing cropland management activities, involves the use of fossil fuels for vehicles and equipment. This usage results in direct emissions of CO_2. Using emission factors developed with the composite modeling approach

[55] Certain parameters required for project eligibility and quantification are contained in a separate document, *Grassland Project Parameters*, available at: http://www.climateactionreserve.org/how/protocols/grassland/.
[56] For additional details regarding the pathways of N_2O emissions due to fertilizer use, refer to the Reserve's Nitrogen Management Project Protocol, available online: http://www.climateactionreserve.org/how/protocols/nitrogen-management/.

described in Appendix B, baseline emissions of CO_2 for fossil fuel usage are estimated for each stratum. If the project is located in a jurisdiction where GHG emissions from mobile sources are subject to a binding emissions cap (such as California[57]), then those projects may not claim emission reductions for this source, and must use a value of zero for $CO_{2,BL}$.

Equation 5.5. Baseline CO_2 Emissions from Fossil Fuel

$$CO_{2,BL} = \sum_{s}^{S} \left(BRC_{CO_2,s} \times \frac{10.15}{1000} \times Area_s \right)$$

Where, Units

$CO_{2,BL}$	=	Baseline emissions due to fossil fuel combustion	tCO_2e
$BRC_{CO2,s}$	=	Annual baseline rate of fossil fuel consumption for stratum *s* (refer to companion tables,[58] selecting the appropriate stratum and time category)	gal/ac/yr
10.15	=	Emission factor for diesel (distillate fuel #2)[59]	kg CO_2/gal
1000	=	Conversion factor	kg/t

5.2.4 Discount Factors

There are two discount factors that are applicable to the quantification of baseline emissions, DF_{conv} and DF_{σ}. DF_{conv} represents the uncertainty of using a standardized financial additionality threshold to represent the likelihood of the baseline conversion scenario. As the cropland premium decreases, uncertainty around the likelihood of baseline conversion increases. Equation 5.6 explains how to determine the value of this discount based on the value of the cropland premium for the county in which the project area is located (found in the companion tables[60]). In Equation 5.2, this discount is applied to the entire estimate of baseline emissions.

Equation 5.6. Discount Factor for the Uncertainty of Baseline Conversion

$$DF_{conv} = \left(1 - \frac{CP - FT_l}{FT_u - FT_l}\right) \times 50\%$$

Where, Units

DF_{conv}	=	Discount factor for the uncertainty of baseline conversion	%
CP	=	Cropland premium for the county where the project is located	%
FT_l	=	Lower threshold for financial additionality (Section 3.3.1.1)	%
FT_u	=	Upper threshold for financial additionality (Section 3.3.1.1)	%
50%	=	Maximum value of DF_{conv}	

DF_{σ} is meant to embody the uncertainty contained within the modeling of the baseline emission factors. The baseline emissions quantified in this protocol are discounted to account for

[57] Additional information regarding the California cap-and-trade program is available at: http://www.arb.ca.gov/cc/capandtrade/capandtrade.htm.
[58] See the Reserve's Grassland Project Protocol webpage at: http://www.climateactionreserve.org/how/protocols/grassland/
[59] 40 CFR Part 98 Subpart C Table C-1.
[60] See the Reserve's Grassland Project Protocol webpage at: http://www.climateactionreserve.org/how/protocols/grassland/.

increasing uncertainty about input assumptions and model outputs into the future. Uncertainty arises due to anticipated but unknown shifts in practices in, among other things, tillage, cropping, and nitrogen management, and the interaction of agricultural systems with a changing climate. Model inputs and outputs are expected to accurately reflect baseline conditions in early years, but have greater uncertainty in future years. Accordingly, the quantification of baseline emissions is discounted , with the discount increasing through time in accordance with increasing uncertainty. The value of DF_σ for a given year is found in the separate file containing the companion tables.[61] If the modeling exercise is updated in the future, it is likely that this discount schedule would reset back to 1% for new projects that would use the updated emission factors. The discount factor is assigned based on the year of the beginning date of the reporting period (i.e., a reporting period which begins on May 9, 2019 would apply the discount listed for 2019 for an entire 12-month reporting period, even though a portion of the period is in the calendar year 2020).

5.3 Quantifying Project Emissions

Project emissions are actual GHG emissions that occur within the GHG Assessment Boundary as a result of the project activity. Project emissions must be quantified every reporting period on an *ex post* basis. In certain cases where these emissions are determined to be *de minimis*,[62] this protocol specifically allows for the Project Owner to use an alternative estimation methodology. Unless otherwise specified, project emission equations cover the entire reporting period, regardless of whether it covers a full year.

Equation 5.7. Project Emissions

$$\boldsymbol{PE = BU_{PR} + FF_{PR} + FE_{PR} + GR_{PR} + LE}$$

Where,

			Units
PE	=	Project emissions, rounded to the nearest whole number	tCO_2e
BU_{PR}	=	Emissions from burning in the project scenario (Equation 5.8)	tCO_2e
FF_{PR}	=	Emissions from fossil fuel and electricity use in the project scenario (Equation 5.9)	tCO_2e
FE_{PR}	=	Emissions from organic fertilizer use in the project scenario (Equation 5.10)	tCO_2e
GR_{PR}	=	Emissions from livestock grazing in the project scenario (Equation 5.11)	tCO_2e
LE	=	Leakage emissions (Equation 5.12)	tCO_2e

5.3.1 Project Emissions from Burning

The project scenario for a grassland project may involve periodic burning, either prescribed or accidental. Regardless of the reason for the fire, the combustion of aboveground biomass results in emissions of CO_2, CH_4, and N_2O. The CO_2 emissions from grass burning are considered biogenic and are excluded from this quantification. The project emissions of CH_4 and N_2O must be estimated using Equation 5.8.

[61] Certain parameters required for project eligibility and quantification are contained in a separate document, *Grassland Project Parameters*, available at: http://www.climateactionreserve.org/how/protocols/grassland/.
[62] For the purposes of this protocol, emissions are *de minimis* if they are less than the relevant materiality threshold when applied to the overall calculation of emission reductions. The materiality threshold for projects is defined in the Verification Program Manual, available online at: http://www.climateactionreserve.org/how/verification/verification-program-manual/.

Equation 5.8. Project Emissions from Burning

$$BU_{PR} = \sum_{S}\left[\left(Area_{burn,s} \times DM_s \times \frac{2.3}{1000000} \times GWP_{CH_4}\right) + \left(Area_{burn,s} \times DM_s \times \frac{0.21}{1000000} \times GWP_{N_2O}\right)\right]$$

Where,			Units
BU_{PR}	=	Emissions from burning in the project scenario	tCO_2e
S	=	Total number of strata	
s	=	Individual stratum	
$Area_{burn,s}$	=	Area of stratum *s* that was burned	acres
DM_s	=	Amount of aboveground dry matter in stratum *s* (refer to companion tables,[63] selecting the appropriate stratum and time period)	kg/acre
2.3	=	Emission factor for methane from biomass burning (6)	g/kg dry matter
0.21	=	Emission factor for nitrous oxide from biomass burning (6)	g/kg dry matter
GWP_{CH4}	=	100-year global warming potential for methane (Table 5.1).	tCO_2e/tCH_4
GWP_{N2O}	=	100-year global warming potential for nitrous oxide (Table 5.1)	tCO_2e/tN_2O
1000000	=	Conversion factor	g/t

5.3.2 Project Emissions from Fossil Fuel and Electricity Use

In the case that the project activities include the use of mobile or stationary equipment or vehicles that consume fossil fuels or electricity, these project emissions are estimated using Equation 5.9. However, if the project can demonstrate that the total value of FF_{PR} is reasonably expected to be *de minimis* (i.e., less than the relevant materiality threshold[64]), these emissions may be estimated through a conservative method proposed by the Project Owner and deemed acceptable by the verifier.

[63] See the Reserve's Grassland Project Protocol webpage at: http://www.climateactionreserve.org/how/protocols/grassland/.
[64] Materiality thresholds for Reserve projects are specified in the Reserve Verification Program Manual, available at: http://www.climateactionreserve.org/how/verification/verification-program-manual/.

Equation 5.9. Project Emissions from Fossil Fuels and Electricity

$$FF_{PR} = \frac{\sum_f (QF_f \times PEF_{FF,f})}{1000} + \frac{(QE \times PEF_{EL})}{1000}$$

Where,

			Units
FF_{PR}	=	Carbon dioxide emissions due to fossil fuel combustion and electricity use in the project scenario	tCO_2e
QF_f	=	Quantity of fossil fuel type *f* consumed	volume
$PEF_{FF,f}$	=	Project emission factor for fossil fuel type *f* (refer to companion tables)[65]	$kgCO_2$/volume fossil fuel
1000	=	Conversion factor	kg/t
QE	=	Quantity of electricity consumed during the reporting period	MWh
PEF_{EL}	=	Carbon emission factor for electricity used, referenced from the most recent U.S. EPA eGRID emission factor publication.[66] Projects shall use the annual total output emission rates for the subregion where the project is located	kg CO_2/MWh

5.3.3 Project Emissions from Organic Fertilizer Use

Certain grasslands may see ecosystem improvements or possibly even enhanced carbon sequestration (not credited under this protocol) following the addition of organic soil amendments (10). In the case that the project activities include the application of organic fertilizer (such as compost or manure), the project emissions of N_2O are estimated using Equation 5.10. This equation quantifies the total direct and indirect emissions of N_2O related to the application of organic fertilizers through the use of project-specific activity data and default emission factors. Additional information regarding the default emission factors used in the next two equations can be found in Appendix C.

Accounting for leaching is required for counties where, on average, the annual precipitation exceeds 80% of annual potential evapotranspiration. This protocol assigns the leaching factor based on an analysis carried out for the annual U.S. GHG Inventory which identifies the probability of leaching on non-irrigated land for every county (13). The results of this analysis are displayed in Figure 5.2 and are contained within the county-level companion tables.[67] Project Owners should refer to Figure 5.2 and the companion tables to determine if their project must account for leaching.[68] Accounting for leaching is also required for any projects which employ irrigation on the project area during the reporting period.

[65] This information can be found in the *Grassland Project Parameters*, document available at: http://www.climateactionreserve.org/how/protocols/grassland/.
[66] Available online at: http://www.epa.gov/cleanenergy/energy-resources/egrid/
[67] Ibid.
[68] Ibid.

Figure 5.2. U.S. Counties Where Nitrogen Leaching is Expected to Occur

Equation 5.10. Project Emissions from Fertilizer Use

$$FE_{PR} = \left(\sum_{C} QF_{PR,c} \times NC_c\right) \times (0.012 + Leach) \times \frac{44}{28} \times GWP_{N_2O} \div 1000$$

Where, Units

FE_{PR}	=	Direct and indirect nitrous oxide emissions from organic fertilizer use in the project scenario	tCO_2e
C	=	Total number of types of organic fertilizer applied, other than manure from grazing livestock	
$QF_{PR,c}$	=	Quantity of fertilizer type *c* applied	kg
NC_c	=	Nitrogen content of fertilizer type *c*	kg N/kg
0.012	=	Default factor representing the direct emission factor of N_2O from organic fertilizer, the fraction of N which is volatilized, and the indirect emission factor for N volatilization and deposition	
Leach	=	Default factor for the fraction and emission factor for N_2O emissions due to leaching. Equal to **0.00225** for projects that are required to use this factor, and **0** for all other projects. Refer to the companion tables[69] to determine whether leaching must be quantified for the county where the project is located. The 0.00225 factor must also be used when irrigation is employed	
$\frac{44}{28}$	=	Molar mass ratio of N_2O to N	kg N_2O/kg N_2O-N
GWP_{N2O}	=	100-year global warming potential for N_2O (Table 5.1)	tCO_2e/tN_2O
1000	=	Conversion factor	kg/t

[69] Certain parameters required for project eligibility and quantification are contained in a separate document, *Grassland Project Parameters*, available at: http://www.climateactionreserve.org/how/protocols/grassland/.

5.3.4 Project Emissions from Grazing

It is likely that grasslands projects include livestock grazing on the project area in the project scenario, leading to enteric methane and manure (methane and nitrous oxide) emissions that would not exist in the baseline scenario. These emissions are quantified using Equation 5.11 and the guidance in Box 5.3. For the purposes of this equation, the “grazing season” is defined as the period of time between the first and last grazing days of the reporting period.

Equation 5.11. Project Emissions from Livestock Grazing

$$GR_{PR} = N_2O_{MN} + CH_{4,MN} + CH_{4,ENT}$$

Where,			Units
GR_{PR}	=	Project emissions from grazing activities in the project area	tCO_2e
N_2O_{MN}	=	N_2O emissions from manure deposited by grazing animals	tCO_2e
$CH_{4,MN}$	=	CH_4 emissions from manure deposited by grazing animals	tCO_2e
$CH_{4,ENT}$	=	CH_4 emissions from enteric fermentation in grazing animals	tCO_2e

$$N_2O_{MN} = \sum_{L}\left(AGD_l \times Nex_l \times (0.022 + Leach) \times \frac{44}{28} \times GWP_{N_2O} \div 1000\right)$$

Where,			Units
L	=	Total number of livestock categories in the project scenario	
AGD_l	=	Animal grazing days for livestock category *l* (see Box 5.3)	animal days
Nex_l	=	Nitrogen excreted by grazing animals in livestock category *l*	kg N/head/day
0.22	=	Default factor representing the emission factor of nitrogen from manure, the fraction of N which is volatilized, and the emission factor for N volatilization. Additional details can be found in Appendix C.	
Leach	=	Default factor for the fraction and emission factor for N_2O emissions due to leaching. Equal to **0.00225** for projects which are required to use this factor, and **0** for all other projects. Refer to the companion tables to determine whether leaching must be quantified for the county where the project is located.[70] The 0.00225 factor must also be used when irrigation is employed.	
$^{44}/_{28}$	=	Molar mass ratio of N_2O to N	N_2O/N
GWP_{N2O}	=	100-year global warming potential for N_2O (Table 5.1)	CO_2e/N_2O
1000	=	Conversion factor	kg/t

$$CH_{4,MN} = \sum_{L}\left(AGD_l \times VS_l \times B_{0,l} \times MCF_{PRP} \times \rho_{CH_4} \times GWP_{CH_4} \div 1000\right)$$

Where,			Units
VS_l	=	Volatile solids excreted by grazing animals in category *l*	kg VS/animal/day
$B_{0,l}$	=	Maximum methane potential for manure from category *l*	m^3 CH_4/kg VS
MCF_{PRP}	=	Methane conversion factor for pasture/range/paddock manure management, dependent on average temperature during grazing season	%
ρ_{CH4}	=	Density of methane at 1 atm and the average temperature during the grazing season	kg/m^3
GWP_{CH4}	=	100-year global warming potential for CH_4 (Table 5.1)	CO_2e/CH_4

$$CH_{4,ENT} = \sum_{L}\left(AGD_l \times PEF_{ENT,l}\right) \times GWP_{CH_4} \div 1000$$

Where,			Units
$PEF_{ENT,l}$	=	Project emission factor for enteric methane emissions from livestock category *l* in the project State[70]	kg CH_4/head/day

[70] Default emission factors and parameters can be found in a separate document, *Grassland Project Parameters*, available at: http://www.climateactionreserve.org/how/protocols/grassland/.

Box 5.3. Determining Animal Grazing Days (AGD_l)

Equation 5.11 requires the use of parameter AGD_l, which represents the total number of days that were grazed by a single category of animals. This is the sum of the number of days each animal category was grazed during the relevant time period. A simplified example is below:

Animal Category	Population	Grazing Days	Animal Grazing Days
Bulls	100	240	24,000
Beef Cows	200	240	48,000
Beef Replacements	40	240	9,600

Note: the numbers in this table are fictional used only for illustrative purposes

If the population of each category is not stable over the grazing period, a reasonable approach shall be applied to estimate AGD_l for each category over the relevant time period.

5.3.5 Project Emissions Due To Leakage

Avoided grassland conversion projects would result in leakage if the project activities result in the conversion of other grassland outside of the project area. This would cause the “avoided” baseline emissions to simply shift and occur elsewhere, thus never actually being avoided. The extent to which this occurs depends on the economics of crop production. The project emissions due to leakage represent the probability that the avoided baseline emissions will occur outside of the project area due to the project activities. Calculating a precise value for this probability is both complex and uncertain. As this protocol relies on default baseline assumptions which are composites of multiple baseline scenarios, it is not possible to determine a precise leakage value for each specific project.

Estimates of the leakage effects of grassland conservation are variable. Several studies have examined the Federal Conservation Reserve Program (CRP) to assess “slippage” (leakage) caused by conservation of arable land. One study determined the slippage effect of CRP enrollment to be 20% (i.e., for every 100 acres that are conserved, 20 acres are converted elsewhere) (12). A later study found no slippage effect from CRP enrollment (13). A third study determined that there is a range from 17.5% to 20.6%, depending upon the number of acres enrolled (higher enrollment led to higher slippage), as well as the elasticity of supply of nitrogen fertilizer (inelastic fertilizer supply led to higher slippage) (14). Lastly, another study, attempting to address the disagreement between the first two, used satellite imagery to attempt to estimate the magnitude of this effect, and came up with estimates that ranged from 3% to 11% (15). This is all to say that estimates of leakage from CRP enrollment, a reasonable proxy for avoided grassland conversion, range from 0% to 20%, with evidence to support various values in the middle of that range. Thus, the Reserve has taken a conservative approach, assuming a 20% leakage effect from grassland projects.

Equation 5.12. Project Emissions from Leakage

$$\boldsymbol{LE = 0.2 \times BE}$$

Where,			Units
LE	=	Leakage emissions during the reporting period	tCO_2e
0.2	=	Leakage discount factor	
BE	=	Baseline emissions during the reporting period	tCO_2e

5.4 Ensuring Permanence of GHG Emission Reductions

If a reversal occurs during a reporting period (see Section 3.5), the reversal must be compensated for by retiring CRTs. Specific requirements depend on the whether the reversal was avoidable or unavoidable, as described below. Reversal compensation requirements do not apply to emission reductions unrelated to carbon stored in the project area soils (e.g., CH_4 and N_2O).

Identification of a reversal is a binary decision based on area; either an area is subject to a reversal or not. For example, if the Grassland Owner decides to plow and cultivate a 10-acre portion of the project area, that entire 10-acre portion shall be considered to have experienced a complete and avoidable reversal. If an area is subject to a reversal, then the quantity of soil carbon reversed is considered to be equal to total number of CRTs issued for reversible emission reductions on that specific portion of the project area. For the purposes of this protocol, reversible emission reductions are those related to the avoided loss of organic carbon in soil and belowground biomass (Equation 5.3) for which CRTs were issued for reporting periods during the 100 years prior to the date of the reversal. The quantity of CRTs that must be retired is determined using Equation 5.13.

Equation 5.13. Quantifying Reversals

$$Rev = \sum_{RP} \left[OC_{BL,rev,rp} \times (1 - DF_{conv}) \times (1 - DF_{\rho,rp}) \right]$$

Where, Units

Rev	=	Quantity of emissions due to the reversal	tCO_2e
RP	=	Total number of reporting periods for which CRTs have already been issued to the project	years
rp	=	Specific project reporting periods	
$OC_{BL,rev,rp}$	=	Baseline emissions due to the loss of organic carbon in soil and biomass in reporting period *rp* for the acres affected by the reversal (see below)	tCO_2e
DF_{conv}	=	Discount factor for the uncertainty of baseline conversion	
$DF_{\rho,rp}$	=	Discount factor for the uncertainty of modeling future management practices and climatic conditions for reporting period *rp*	

$$OC_{BL,rev,rp} = \sum_{S,rp-n}^{n=100} \left(OC_{BL,s,rp-n} \times \frac{Area_{rev,s}}{Area_s} \right)$$

Where, Units

$OC_{BL,s,y-n}$	=	Baseline emissions due to the loss of organic carbon and biomass in stratum *s* during reporting period *rp-n* (summed for all strata affected by the reversal and all reporting periods for which CRTs have been issued during the previous 100 years)	tCO_2e
$Area_{rev,s}$	=	Area of stratum *s* affected by the reversal	acres
$Area_s$	=	Total project area in stratum *s*	acres

5.4.1 Avoidable Reversals

Requirements for avoidable reversals are as follows:

1. If an avoidable reversal is identified during annual monitoring, the Project Owner must give written notice to the Reserve within thirty days of identifying the reversal. Additionally, if the Reserve determines that an avoidable reversal has occurred, it shall deliver written notice to the Project Owner.
2. Within thirty days of receiving the avoidable reversal notice from the Reserve, the Project Owner must provide a written description and explanation of the reversal to the Reserve, including a map of the specific area that is affected.
3. Within four months of receiving the avoidable reversal notice, the Project Owner must transfer to the Reserve a quantity of CRTs from its Reserve account equal to the size of the reversal as calculated in Equation 5.13.
    a. The surrendered CRTs must be those that were issued to the grassland project, or that were issued to other grassland projects registered with the Reserve. If there is not a sufficient quantity of grassland CRTs available for compensation, as determined by the Reserve, CRTs issued to a forest project registered with the Reserve are acceptable.
    b. The surrendered CRTs shall be retired by the Reserve and designated in the Reserve software as compensating for an avoidable reversal.

5.4.2 Compensating for Unavoidable Reversals

Requirements for unavoidable reversals are as follows:

1. If the Project Owner determines there has been an unavoidable reversal, it must notify the Reserve in writing of the unavoidable reversal within 30 days of identifying the reversal.
2. The Project Owner must explain the nature of the unavoidable reversal, including a map of the specific area affected, and provide an estimate of the size of the reversal using Equation 5.13.

If the Reserve determines that there has been an unavoidable reversal, it shall retire a quantity of CRTs from the Reserve Grassland Buffer Pool equal to the size of the reversal in metric tons of CO_2.

5.4.3 Contributing to the Grassland Buffer Pool

For each reporting period, the Project Owner must transfer a quantity of credits (determined by Equation 5.14) to the Reserve Grassland Buffer Pool at the time of credit issuance. Credits that enter the buffer pool are never returned to the project directly (except as specified for credits related to $Risk_{SV}$), but instead are held in trust for the benefit of all registered grassland projects, to be used as compensation for unavoidable reversals, as described in Section 5.4.2. Equation 5.14 shall be used to calculate the buffer pool contribution for the project during the reporting period.

The risk of an unavoidable reversal to a grassland project is extremely low. Fires would not typically release the carbon that is stored underground. Catastrophic floods would typically only occur in areas that have already been screened out by the eligibility criteria. Volcanic activity is exceedingly rare in the conterminous U.S., and does not occur in the areas where grassland projects typically occur. Due to the fact that the risk of unavoidable reversals is not significantly differentiated by location or land management, the Reserve has decided to adopt a default buffer pool contribution for all projects that is intended to insure against all types of unavoidable reversals.

In addition to the default contribution, projects may be obligated to make additional contributions to the buffer pool in certain situations. Where the Project Owner has elected to employ a Contract PIA, an additional contribution is required to reflect risks from financial failure; the value of $Risk_{FF}$ in Equation 5.14 shall be 0.1. Where the Grassland Owner has elected to employ a Recorded PIA, and has elected to allow the PIA to be subordinated to subsequent deed restrictions (such as a mortgage), an additional contribution is required to reflect risks from financial failure. If the property owner has employed Recorded PIA Subordination Clause Type 1, the value of this risk is 0. If the property owner has employed Recorded PIA Subordination Clause Type 2, the value of this risk is 0.1.[71] An exception to these rules is made for cases where the Project Owner is a land trust with accreditation through the Land Trust Accreditation Commission,[72] in which case the value of $Risk_{FF}$ shall be 0, regardless of the particular format of the PIA.

Site visits during verification are not mandatory for grassland projects. However, there is risk associated with a project that has never been visited for the purposes of a third-party verification. The Reserve believes that this risk is low enough that the site visit during verification has been made optional. However, an additional buffer pool contribution must be made to account for the increased risk (designated as "$Risk_{SV}$" in Equation 5.14). For each project that has never had a site visit during verification, the value of $Risk_{SV}$ shall be 0.05 until such time that a site visit verification occurs.[73] At that time, the CRTs contributed to the buffer pool due to this requirement shall be returned to the project in the form of either a reduced buffer pool contribution in future reporting periods or a lump sum refund of CRTs from the buffer pool, subject to agreement between the Project Owner and the Reserve. The amount of CRTs to be returned shall be determined by calculating what the buffer pool contributions would have been had the value of $Risk_{SV}$ been 0 for the previous reporting periods. If a site visit occurs during the initial verification, the value of $Risk_{SV}$ shall be 0 for the entire crediting period. This applies equally to individual projects as well as projects participating in a cooperative. For example, if a cooperative contains 10 projects and site visits occur on only 2 of them during the initial verification, the remaining 8 projects are subject to the increased buffer pool contribution, until such time that a site visit is carried out for those projects.

[71] The Project Implementation Agreements are available at: http://www.climateactionreserve.org/how/protocols/grassland/. Details on the buffer pool contribution related to subordination of the Recorded PIA are found in Exhibit E.
[72] Information regarding the Land Trust Accreditation Commission and the requirements for accreditation can be found at: http://www.landtrustaccreditation.org/.
[73] The reporting period during which the site visit occurs shall be the first reporting period not subject to the additional buffer pool contribution.

Equation 5.14. Buffer Pool Contribution to Insure Against Reversals

$$BP = Risk_{rev} \times OC_{BL}$$

Where, Units

BP	=	Project contribution to the buffer pool	tCO_2e
$Risk_{rev}$	=	Risk of reversals, as determined below	%
OC_{BL}	=	Baseline quantity of organic carbon emissions from soil and biomass (Equation 5.3)	tCO_2e

$$Risk_{rev} = 1 - [(1 - 0.02) \times (1 - Risk_{FF}) \times (1 - Risk_{SV})]$$

Where, Units

0.02	=	Default risk of unavoidable reversals, applicable to all projects[74]	fraction
$Risk_{FF}$	=	Additional risk related to financial failure, the value is either 0 or 0.1, as described above.	fraction
$Risk_{SV}$	=	Risk of misstatement by projects which have not had a site visit by a third-party verifier. The value is either 0 or 0.1	fraction

As there are only three risk categories that contribute to $Risk_{rev}$, one of which is mandatory, there are ten possible project scenarios, leading to four possible values for this parameter. The potential project scenarios and the resulting value of $Risk_{rev}$ are listed in Table 5.4.

Table 5.4. Possible Values of $Risk_{rev}$

Default Risk	PIA	Project Owner	$Risk_{FF}$	Site Visit	$Risk_{SV}$	$Risk_{rev}$
0.02	Contract PIA	Accredited land trust	0	Yes	0	**0.020**
0.02	Contract PIA	Accredited land trust	0	No	0.05	**0.069**
0.02	Contract PIA	Other	0.1	Yes	0	**0.118**
0.02	Contract PIA	Other	0.1	No	0.05	**0.162**
0.02	Recorded PIA, Type 1 Subordination Clause	Any	0	Yes	0	**0.020**
0.02	Recorded PIA, Type 1 Subordination Clause	Any	0	No	0.05	**0.069**
0.02	Recorded PIA, Type 2 Subordination Clause	Accredited land trust	0	Yes	0	**0.020**
0.02	Recorded PIA, Type 2 Subordination Clause	Accredited land trust	0	No	0.05	**0.069**
0.02	Recorded PIA, Type 2 Subordination Clause	Other	0.1	Yes	0	**0.118**
0.02	Recorded PIA, Type 2 Subordination Clause	Other	0.1	No	0.05	**0.162**

[74] Based on discussion between and among Reserve staff and external stakeholders regarding the risks of unavoidable reversals to grassland projects. Such risks were determined to be low, but also not zero.

6 Project Monitoring

The Reserve requires a Monitoring Plan to be established for all monitoring and reporting activities associated with the project. The Monitoring Plan serves as the basis for verifiers to confirm that the monitoring and reporting requirements in this section and Section 7 have been and continue to be met, and that consistent, rigorous monitoring and record keeping is ongoing at the project site. The Monitoring Plan must cover all aspects of monitoring and reporting contained in this protocol and must specify how data for all relevant parameters in Table 6.1 are collected and recorded.

At a minimum, the Monitoring Plan shall include a description of ownership of both the property and the emission reductions; the methods and frequency of data acquisition; a record keeping plan (see Section 7.3 for minimum record keeping requirements), and the role of individuals performing each specific monitoring activity. The Monitoring Plan should include QA/QC provisions to ensure that data acquisition and recordkeeping are carried out consistently and with precision.

Finally, the Monitoring Plan must include procedures that the Project Owner follows to ascertain and demonstrate that the project at all times passes the legal requirement test and the Regulatory Compliance Test (Section 3.3.2 and 3.6, respectively).

Project Owners are responsible for monitoring the performance of the project.

6.1 Monitoring Ongoing Eligibility

To maintain eligibility on an ongoing basis, grassland projects must demonstrate that the project area has not been converted into another land use during the reporting period. If the project verification includes a physical site visit, that satisfies the requirements of this section. Otherwise, Project Owners shall refer to the guidance in Section 5.1.3 for guidance on documenting land use in the project area.

6.2 Monitoring Grazing

Livestock grazing is allowed in the project scenario. While low to moderate levels of grazing intensity may have a beneficial effect on the grassland ecosystem and net soil carbon storage (16), overgrazing can be detrimental to both the storage of soil carbon (17) and the health of the grassland ecosystem (18). Project grazing must be limited to moderate levels of intensity, balancing stocking rates with forage production and accounting for site characteristics, including climate variability (especially periods of drought), range condition, slope, distance from water, and the needs of the particular animals (19) (20). This is ensured through a combination of mechanisms:

1. Administrative mechanisms to prevent overgrazing, either:
    a. Prescribed grazing management plan; or,
    b. Legal limitations on grazing intensity; and
2. Monitoring of grazing intensity during the reporting period

CRTs will not be issued for any reporting period during which it is determined that there has been a violation of the administrative mechanism to prevent overgrazing.

6.2.1 Administrative Mechanisms to Prevent Overgrazing

Grassland projects must employ a mechanism to prevent overgrazing which is tailored to the specific conditions of their project and its ecosystem. This could be in the form of a prescribed grazing management plan or legally enforceable limitations on grazing intensity.

6.2.1.1 Prescribed Grazing Management Plan

If there are no legal limitations on grazing intensity (Section 6.2.1.2), the Project Owner must develop and implement a prescribed grazing management plan for livestock grazing on the project area during the reporting period. The plan shall be developed following the principles of NRCS Conservation Practice Standard 528 for Prescribed Grazing, adhering to NRCS-recommended moderate stocking rates or lower.[75] The plan shall be reviewed and approved by either an agent of a relevant state or federal government agency or a professional with certification from either the Society for Range Management[76] or the American Forage and Grassland Council.[77] The management plan must specifically identify the protection of existing soil carbon pools as a management goal. Adherence to the plan shall be reviewed and confirmed by one of the entities listed above during the first reporting period and at least once every six years following the project start date. In years without a government or professional review of adherence to the prescribed grazing management plan, the verifier shall take additional steps to assess the risk of nonconformance. This plan shall be updated to reflect any significant changes to the grazing management practices.

Per Section 3.3.3.2, it may be possible for the project to receive funding to implement a prescribed grazing management plan. A pre-existing grazing management plan does not violate the legal requirement test.

6.2.1.2 Legally Enforceable Limitations on Grazing Intensity

If the project area is subject to legally enforceable limits on grazing intensity, with an explicit mechanism for ongoing monitoring and enforcement, the project is not required to develop and implement a prescribed grazing management plan. For example, an easement recorded on the project area may contain language specifically limiting the intensity of land use activities, with enough detailed stipulations for it to be effectively enforced. Overgrazing would be considered a violation of the terms of the easement, determined through ongoing monitoring, and subject to legal enforcement by the easement holder. The Reserve does not seek to directly enforce the grazing limitations, nor is the verifier expected to directly enforce the grazing limitations. Instead, the verifier may consider the existence of ongoing monitoring and enforcement to represent a legal limit on grazing intensity. Project Owners are also encouraged to voluntarily implement a prescribed grazing management plan as a complement to any legally enforceable limitations on grazing intensity.

6.2.2 Monitoring of Grazing Activities during the Reporting Period

All grazing activities must be documented for the reporting period. For each reporting period, Project Owners must document the type of livestock being grazed and the total animal grazing days for each type (see Box 5.2). Although the unit for quantification is days, the grazing activities do not need to be monitored on a daily basis. Because grazing activities do not vary on a day-to-day basis, less frequent monitoring may be used to estimate the grazing days. The

[75] Available at: http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs143_025729.pdf.
[76] More information is available at: www.rangelands.org.
[77] More information is available at: www.afgc.org.

livestock shall be categorized according to the categories in the *Grassland Project Parameters* spreadsheet.[78] These data are used for the parameter AGD_l in Equation 5.11. The frequency of monitoring and the form of the documentation is not prescribed by this protocol. The verifier shall use professional judgment to confirm with reasonable assurance both that the quantification of project emissions from grazing is conservative, and that grazing activities did not exceed limits on overgrazing, as specified by either Section 6.2.1 or Section 6.2.1.2.

Examples of potential grazing documentation (this list is not comprehensive nor is it intended to define sufficiency of documentation):

- Grazing logs (kept daily, weekly, or monthly) that specify the animal categories, populations, and grazing locations
- Animal purchase and sale records, assuming all animals are grazed on the project area
- Grazing management plan, assuming maximum allowable grazing activity

As an alternative, where the administrative mechanism employed to limit overgrazing (Section 6.2.1) can be reasonably and conservatively used to determine the animal category and maximum allowable population, then the project may conservatively assume that grazing activity was at the maximum. This alternative monitoring approach requires the Project Owner to provide some evidence to allow the verifier to be reasonably assured that the project did not exceed this assumed level. For example, this alternative could be employed by projects where some grazing documentation exists, but it is not sufficient to determine the AGD by animal category.

6.3 Monitoring Project Emission Sources

For fossil fuels and electricity emissions (Equation 5.9), if the Project Owner can demonstrate that the total value of $CO_{2,PR}$ is reasonably expected to be *de minimis* (i.e., less than the relevant materiality threshold), these emissions may be estimated through a conservative method proposed by the Project Owner and deemed acceptable by the verifier. If not required for the alternative method, the monitoring of fossil fuels and electricity as described in this section is not required.

Otherwise, for each reporting period, the Project Owner must provide documentation for the following parameters used for the quantification of project emissions:

- Total acres burned and cause(s) of fire(s)
- Animal grazing days by livestock category
- Mass of organic fertilizer applied (other than manure from grazing), by type
- Nitrogen content of organic fertilizer applied, by type
- Purpose, type, and quantity of fossil fuels used (e.g., tractor, diesel, 100 gallons)
- Purpose, source, and quantity of electricity (e.g., electric fence, MROW grid, 100 kWh)

For projects that employ additions of organic fertilizer (beyond the manure from on-site grazing of livestock), it is strongly encouraged that the project develop a nutrient management plan. Nutrient management plans should consider the principles contained in NRCS Conservation Practice Standard 590 for Nutrient Management.[79] Where a project also incorporates irrigation and/or grazing, such activities should be taken into account in developing any nutrient

[78] Available at: http://www.climateactionreserve.org/how/protocols/grassland/.
[79] Available at: http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb1046896.pdf.

management plan for the project. Development of and adherence to a nutrient management plan is not required, but is strongly recommended.

6.4 Monitoring Ecosystem Health

As described in Section 3.7, grassland projects are subject to forces, both natural and cultural, active and passive, that could impair the long-term health and functioning of the rangeland system. Thus, it is required that projects undergo a periodic assessment of rangeland health according to the assessment protocol described in the Bureau of Land Management's Technical Reference 1734-6, "Interpreting Indicators of Rangeland Health" (21).[80] A rangeland health assessment must be submitted for review during one of the first two project verifications. Subsequent assessments may occur as frequently as desired by the Project Owner, with a minimum frequency of once every six years.[81] These assessments are only required during the crediting period, and are not required during the permanence period, although it is strongly recommended that the practice be continued on a voluntary basis. If the project area is already subject to periodic rangeland health assessments according to TR 1734-6, then the most recent assessment may be submitted during the initial project verification, provided that it is dated no more than six years prior to the end of the initial reporting period.

The reference conditions for the project area may be determined using the appropriate Ecological Site Description (ESD).[82] If the ESD does not contain specified reference conditions for the project area, they may be developed following the guidance in TR 1734-6. The rangeland health assessment must be conducted by an appropriately-trained individual. The result of the assessment is the rating of 17 different metrics by the severity of their departure from the expected reference condition, categorized into five levels:

1. None to Slight
2. Slight to Moderate
3. Moderate
4. Moderate to Extreme
5. Extreme to Total

The Reserve understands that heterogeneity of ecosystems, land use history, and land management practices mean that it is likely that the project area exhibits at least slight deviation from the reference condition for at least one, if not several, rangeland health metrics. Projects are not required to meet reference conditions for rangeland health metrics.

For any metric that is assessed to be at the third level ("Moderate"), the Project Monitoring Plan must be updated prior to the next verification to reflect planned management changes to address that metric, with a minimum goal of preventing further departure from the reference condition. A preferred goal would be a return to reference condition.

For any metric that is assessed to be at the fourth or fifth levels ("Moderate to Extreme" or "Extreme to Total") of departure from the reference condition, the Project Monitoring Plan must be updated prior to the next verification to reflect planned management changes to address that

[80] The assessment protocol, associated documents, and information regarding training opportunities are available online at: http://jornada.nmsu.edu/monit-assess/manuals/assessment (accessed 10/14/16).
[81] The result of this schedule is that if a project elects to follow the most relaxed verification schedule (once every six years), there will be at least one rangeland health assessment during every verification period.
[82] An ESD may be obtained from the USDA NRCS at: https://esis.sc.egov.usda.gov/Welcome/pgESDWelcome.aspx (accessed 10/14/16).

metric, with a goal of improving that metric toward reference condition. The subsequent rangeland health assessment must show improvement in these metrics. If a project does not improve (or declines) in these metrics at the next assessment, the Project Owner must notify the Reserve, which shall determine whether the project is eligible for crediting for the current reporting period. Projects that can demonstrate rangeland health impairment occurred despite reasonable, good-faith efforts in land management may not need to forfeit credits. However, significant degradation in rangeland health could be considered a reversal, despite the lack of a specific disturbance event. Refer to Section 3.7 for additional information regarding the consequences of significantly degraded rangeland health.

Management planning for rangeland health should explicitly include management of livestock grazing.

6.5 Monitoring Project Cooperatives

There can be gains in efficiency through centralized monitoring for project cooperatives. A Cooperative Developer may organize their monitoring plan such that information from individual projects is collected and processed together. However, all information and documentation must be organized in such a manner that the verifier can assess that the requirements of this protocol have been met for each individual project. For example, it is acceptable to submit a single spreadsheet of grazing data for the cooperative, but the grazing data for each individual project must still be clearly defined within that spreadsheet.

6.6 Monitoring Parameters

Prescribed monitoring parameters necessary to calculate baseline and project emissions are provided in Table 6.1.

Table 6.1. Grassland Project Monitoring Parameters

Eq. #	Parameter	Description	Data Unit	Calculated (C) Measured (M) Reference (R) Operating Records (O)	Measurement Frequency	Comment
General Project Parameters						
	Project Definition	Must confirm project land use has not changed		R, O	Each reporting period	Information used to asses that the project area remains as grassland.
	Eligibility	Must satisfy all requirements of the Eligibility section		N/A	Each reporting period	Information used to assess satisfaction of the requirements of Section 3.

Eq. #	Parameter	Description	Data Unit	Calculated (C) Measured (M) Reference (R) Operating Records (O)	Measurement Frequency	Comment
	Regulations	Project Owner attestation of compliance with regulatory requirements relating to the project	All applicable regulations	N/A	Each reporting period	Information used to: 1) Demonstrate ability to meet the legal requirement test – where regulation would prevent conversion of project area. 2) Demonstrate compliance with associated environmental rules, e.g., criteria pollutant limits.
Equation 5.3, Equation 5.4	S	Total number of strata relevant to the project area	strata	R	Once[83]	Information used to determine acres assigned to each relevant stratum.
Equation 5.1	ER	Emission reductions	tCO_2e	C	Per reporting period	Emission reductions are quantified once per reporting period per project. May be summed for reporting of a project cooperative.
Equation 5.5	Area	Area of the entire project	acres	M	Once[83]	The project area is measured using GIS.
Equation 5.3, Equation 5.4	$Area_s$	Area of project in stratum *s*	acres	M	Once[83]	The area of each stratum is measured using GIS.
Baseline Emission Calculation Parameters						
Equation 5.1, Equation 5.2, Equation 5.12	BE	Baseline emissions	tCO_2e	C	Per reporting period	Calculated based on default factors.
Equation 5.2, Equation 5.3, Equation 5.14	OC_{BL}	Baseline emissions due to loss of organic carbon from soil and belowground biomass	tCO_2e	C	Per reporting period	Calculated for each stratum using default emission factors.

[83] This parameter would only change if a portion of the project area was subsequently removed from the project and excluded from future quantification.

Eq. #	Parameter	Description	Data Unit	Calculated (C) Measured (M) Reference (R) Operating Records (O)	Measurement Frequency	Comment
Equation 5.2, Equation 5.4	N_2O_{BL}	Baseline emissions of nitrous oxide	tCO_2e	C	Per reporting period	Calculated for each stratum using default emission factors.
Equation 5.2, Equation 5.5	$CO_{2,BL}$	Baseline emissions of carbon dioxide	tCO_2e	C	Per reporting period	Calculated for each stratum using default consumption rates.
Equation 5.2, Equation 5.6, Equation 5.13	DF_{conv}	Discount factor for the uncertainty of conversion	%	R	Once	The value of this uncertainty is based on the performance standard test.
Equation 5.2, Equation 5.13	DF_{σ}	Discount factor for the uncertainty of modeling future management practices and climatic conditions	%	R	Per reporting period	The value of this uncertainty is related to the amount of time that has passed since the baseline modeling was completed.
Equation 5.2	Pro	Pro-rating factor	%	C	Per reporting period	For reporting periods which do not cover an entire year
Equation 5.3	CP	Cropland premium for the project site county	%	R	Once	The cropland premium for the project site county may be referenced from the companion tables.[84]
Equation 5.3	$BEF_{OC,s,y}$	Annual baseline emission factor for organic carbon	kg CO_2e/ac/yr	R	Per reporting period	Default factor based on stratum.
Equation 5.4	$BEF_{N2O,s}$	Annual baseline emission factor for N_2O emissions in stratum *s*	kg N_2O/ac/yr	R	Per reporting period	Default factor based on stratum.
Equation 5.5	BRC_{CO2}	Annual baseline rate of consumption of diesel fuel due to cultivation activities	gal/ac/yr	R	Per reporting period	Default consumption rate based on stratum.
Equation 5.5	EF_{FF}	Emission factor for diesel fuel	kg CO_2/gal	R	Per reporting period	Default value for all projects.

[84] Certain parameters required for project eligibility and quantification are contained in a separate document, *Grassland Project Parameters*, available at: http://www.climateactionreserve.org/how/protocols/grassland/.

Eq. #	Parameter	Description	Data Unit	Calculated (C) Measured (M) Reference (R) Operating Records (O)	Measurement Frequency	Comment
Project Emission Calculation Parameters						
Equation 5.7	PE	Project emissions	tCO_2e	C	Per reporting period	Actual emissions in the project area during the reporting period.
Equation 5.7, Equation 5.8	BU_{PR}	Emissions from burning in the project scenario	tCO_2e	C	Per reporting period	Calculated only in the case of a fire during the reporting period.
Equation 5.7, Equation 5.9	FF_{PR}	Emissions from fossil fuels and electricity in the project scenario	tCO_2e	C	Per reporting period	Calculated only if fossil fuels or electricity are used for the project during the reporting period.
Equation 5.7, Equation 5.10	FE_{PR}	Emissions from fertilizer use in the project scenario	tCO_2e	C	Per reporting period	Calculated only if fertilizer is applied on the project area during the reporting period.
Equation 5.7, Equation 5.11	GR_{PR}	Emissions from livestock grazing in the project scenario	tCO_2e	C	Per reporting period	Calculated only if livestock grazing occurs on the project area during the reporting period.
Equation 5.7, Equation 5.12	LE	Emissions from leakage in the project scenario	tCO_2e	C	Per reporting period	Based on a default factor for leakage.
Equation 5.8	$Area_{burn,s}$	Area of stratum *s* that was burned	acres	O	Per fire event	Estimated through either remote sensing or on-site measurement.
Equation 5.8	DM_s	Amount of aboveground dry matter in stratum *s*	kg/ac	R	Per reporting period	Default factor based on stratum.
Equation 5.9	QF_f	Quantity of fossil fuel type *f* consumed	volume	O	Per reporting period	Includes fossil fuels consumed for any activities on the project area.
Equation 5.9	$PEF_{FF,f}$	Project emission factor for fossil fuel type *f*	kg CO_2/volume fuel	R	Per reporting period	Default emission factors provided.
Equation 5.9	QE	Quantity of electricity consumed during the reporting period	MWh	O	Per reporting period	Includes any electricity consumed on the project area.

Eq. #	Parameter	Description	Data Unit	Calculated (C) Measured (M) Reference (R) Operating Records (O)	Measurement Frequency	Comment
Equation 5.9	PEF_{EL}	Emission factor for electricity consumed	kg CO_2/MWh	R	Per reporting period	Referenced from the most recent U.S. EPA eGRID emission factor publication.[85] Projects shall use the annual total output emission rates for the subregion where the project is located.
Equation 5.10	C	Total number of types of organic fertilizer applied, other than manure from grazing livestock	Categories	O	Per reporting period	Must be documented if fertilizer is applied on the project area during the reporting period.
Equation 5.10	QF_{PR}	Quantity of organic fertilizer type *c* applied	kg	O	Per reporting period	Must be documented if fertilizer is applied on the project area during the reporting period.
Equation 5.10	NC_c	Nitrogen content of fertilizer type *c*	kg N/kg fertilizer	O	Per reporting period	Must be documented if fertilizer is applied on the project area during the reporting period.
Equation 5.10, Equation 5.11	Leach	Default factor for the fraction and emission factor for N_2O emissions due to leaching	N/A	R	Once	Default factor based on the county where the project area is located. Default factor also be used when irrigation employed in project reporting period.
Equation 5.11	N_2O_{MN}	N_2O emissions from livestock grazing	tCO_2e	C	Per reporting period	Based on AGD for each livestock category using default emission factors.
Equation 5.11	$CH_{4,MN}$	CH_4 emissions from manure	tCO_2e	C	Per reporting period	Based on AGD for each livestock category using default emission factors.

[85] Available online at: http://www.epa.gov/cleanenergy/energy-resources/egrid/

Eq. #	Parameter	Description	Data Unit	Calculated (C) Measured (M) Reference (R) Operating Records (O)	Measurement Frequency	Comment
Equation 5.11	$CH_{4,ENT}$	CH_4 emissions from enteric fermentation	tCO_2e	C	Per reporting period	Based on AGD for each livestock category using default emission factors.
Equation 5.11	L	Total number of livestock categories	Categories	O	Per reporting period	Documented for every reporting period where livestock are grazed on the project area.
Equation 5.11	AGD_l	Animal grazing days for livestock category *l*	Animal days	O	Per reporting period	Documented for every reporting period where livestock are grazed on the project area.
Equation 5.11	Nex_l	Nitrogen excreted by animals in livestock category *l*	kg N/animal grazing day	R	Per reporting period	Default factors based on livestock category and project state.
Equation 5.11	VS_l	Volatile solids excreted by animals in livestock category *l*	kg VS/animal grazing day	R	Per reporting period	Default factors based on livestock category and project state.
Equation 5.11	$B_{0,l}$	Maximum CH_4 potential for manure from animal category *l*	m^3 CH_4/kg VS	R	Per reporting period	Default factors based on livestock category.
Equation 5.11	MCF_{PRP}	CH_4 conversion factor for pasture/range/paddock manure management	%	R	Per reporting period	Default value based on average ambient temperature during the grazing season.
Equation 5.11	ρ_{CH4}	Density of CH_4 at 1 atm pressure and the average ambient temperature during the grazing season	kg/m^3	R	Per reporting period	Based on average ambient temperature during the grazing season.
Equation 5.11	$PEF_{ENT,l}$	Project emission factor for enteric methane emissions from livestock category *l*	kg CH_4/animal grazing day	R	Per reporting period	Default factors based on livestock category and project state.

Eq. #	Parameter	Description	Data Unit	Calculated (C) Measured (M) Reference (R) Operating Records (O)	Measurement Frequency	Comment
Equation 5.13	Rev	Quantity of emissions due to a reversal	tCO_2e	C	Per reversal event	Any event, avoidable or unavoidable, which causes a loss of belowground organic carbon results in a reversal of CRTs which have been issued. Reversals must be quantified and compensated for.
Equation 5.13	Y	Number of years for which CRTs have already been issued	years	O	Per reversal event	The magnitude of a reversal is related to the affected area and the number of CRTs which have already been issued.
Equation 5.13	$OC_{BL,rev,rp}$	Baseline emissions of organic carbon in soil and biomass in reporting period *y* for the acres affected by the reversal	tCO_2e	C	Per reversal event	The quantity of CRTs related to belowground organic carbon affected by the reversal.
Equation 5.14	BP	Buffer pool contribution	tCO_2e	C	Per reporting period	Based on risk rating for the project.
Equation 5.14	$Risk_{rev}$	Risk of unavoidable reversals	%	C	Per reporting period	Includes a default risk plus additional project-specific risks.
Equation 5.14	$Risk_{FF}$	Risk related to financial failure	%	R	Once, unless the PIA is updated to change the subordination clause	The value is determined based on the specific subordination clause that is included in the PIA. Details can be found in Exhibit E of the PIA.
Equation 5.14	$Risk_{SV}$	Risk related to site visit schedule	%	R	Per reporting period	The value is determined based on whether the project or cooperative adheres to the recommended minimum site visit schedule.

7 Reporting Parameters

This section provides requirements and guidance on reporting rules and procedures. A priority of the Reserve is to facilitate consistent and transparent information disclosure across projects.

7.1 Time Periods for Reporting

Table 7.1 summarizes the various time periods that are relevant to AGC projects. Project Owners should recognize that recurring periods (such as reporting periods or verification periods) must always be contiguous, such that there are no gaps between recurring periods. CRTs can only be issued upon approval of a verification report by the Reserve.

Table 7.1. Guide to Relevant Time Periods for Grassland Projects

Description	Time Period	Protocol Section
Project lifetime	Up to 150 years	2.2
Conservation easement term	Perpetual	2.2
Pre-project land use history	No less than 10 years prior to project start date	2.2
Crediting period	No more than 50 years following project start date	3.4
Reporting period (first)	No more than 24 months	7.4
Reporting period (subsequent)	No more than 12 months	7.4
Verification period (first)	First reporting period	7.4
Verification period (subsequent)	No more than 6 reporting periods	7.4
Permanence period	100 years following crediting period	3.5
Monitoring period (easement enforcement)	No more than 6 years	7.5.1
Monitoring period (outside of easement enforcement)	No more than 3 years	7.5.2
Verification period (outside of easement enforcement)	No more than 15 years	7.5.2

7.2 Project Documentation

Project Owners must provide the following documentation to the Reserve in order to register a grassland project:

- Project Submittal form (or Cooperative Submittal form)*
- Property ownership documentation*
- Project conservation easement
- Project Implementation Agreement
- Project area map (this map is public; it is only required to show the outer extent of the project area and is not required to be in a georeferenced format)*
- Signed Attestation of Title form
- Signed Attestation of Voluntary Implementation form
- Signed Attestation of Regulatory Compliance form
- Verification Report
- Verification Statement

** Denotes items that are required at the time of project submittal.*

Project Owners must provide the following documentation for each verification period during the crediting period in order for the Reserve to issue CRTs for quantified GHG reductions:

- Verification Report
- Verification Statement
- Signed Attestation of Title form
- Signed Attestation of Voluntary Implementation form
- Signed Attestation of Regulatory Compliance form
- Signed Project Implementation Agreement (for the initial verification) or signed, amended Project Implementation Agreement (for subsequent verifications)
- Georeferenced project boundary map (this map is private; it must delineate the actual polygons of the eligible project area, and must be a shapefile or KML format)

Documentation requirements for the Permanence Period are explained in Section 7.5.

At a minimum, the above project documentation (except as noted) is available to the public via the Reserve's online registry. Further disclosure and other documentation may be made available on a voluntary basis through the Reserve. Project submittal forms can be found at http://www.climateactionreserve.org/how/program/documents/.

7.3 Record Keeping

For purposes of independent verification and historical documentation, Project Owners are required to keep all information outlined in this protocol for a period of 10 years after the information is generated or 7 years after the last verification. This information is not publicly available, but may be requested by the verifier or the Reserve.

System information the Project Owner shall retain includes:

- Detailed, georeferenced project maps (created per guidance in Section 2.2.1)
- Ongoing monitoring reports or documentation related to the conservation easement
- All data inputs for the calculation of the project emission reductions, including all required sampled data
- Documentation of the continued conservation of the grassland cover in the project area (see Section 6.1)
- Copies of all permits, Notices of Violations, and any relevant administrative or legal consent orders dating back at least 3 years prior to the project start date
- Executed Attestation of Title, Attestation of Regulatory Compliance, and Attestation of Voluntary Implementation forms
- Onsite fossil fuel use records, if applicable
- Onsite grid electricity use records, if applicable
- Grazing management plan, if applicable
- Nutrient management plan, if applicable
- Grazing management records
- Fertilizer use records, if applicable
- Documentation of fires, if applicable
- Results of annual CO_2e reduction calculations
- Initial and annual verification records and results

7.4 Reporting Period and Verification Cycle

The reporting period is the length of time over which GHG emission reductions from project activities are quantified. Project Owners must report GHG reductions resulting from project activities during each reporting period. A reporting period may not exceed 12 months in length, except for the initial reporting period, which may cover up to 24 months. The Reserve accepts verified emission reduction reports on a sub-annual basis, should the Project Owner choose to have a sub-annual reporting period and verification schedule (e.g., monthly, quarterly, or semi-annually). However, it is recommended that projects follow a calendar year reporting schedule to simplify the application of the quantification and monitoring requirements. Reporting periods must be contiguous; there must be no gaps in reporting during the crediting period of a project once the first reporting period has commenced.

The verification period is the length of time over which GHG emission reductions from project activities are verified. The initial verification period for a grassland project is limited to one reporting period. Subsequent verification periods may cover up to six reporting periods. It is required that a project verification occur at least every six years during a project's crediting period. CRTs will not be issued for reporting periods that have not been verified. Project Owners may choose to verify more frequently than every six reporting periods. For any reporting period that ends prior to the end of the verification period (i.e., years 1-5 of a 6 year verification period), an interim monitoring report must be submitted to the Reserve no later than 90 days following the end of the relevant reporting period. The interim monitoring report shall contain a summary of ownership (describing the entities and relationships detailed in Section 2.3), evidence of land use (as described in Section 5.1.3), and basic documentation of land management activities and project emissions during the relevant reporting period.[86] See Section 7.5 for guidance on reporting and verification activities after the crediting period is concluded.

To meet the verification deadline, the Project Owner must have the required verification documentation (see Section 7.2) submitted within 12 months of the end of the verification period. The end date of any verification period must correspond to the end date of a reporting period. No more than six reporting periods (a maximum of 72 months) can be verified at once during the project's crediting period.

7.5 Reporting and Verification of Permanence

When the crediting period for a grassland project ends, the project enters the permanence period. Per Section 3.5, the project area must be monitored to ensure against reversals for a period of 100 years following the last issuance of CRTs related to carbon pools at the project site (i.e., soil organic carbon). During the permanence period, no emission reductions are claimed and no new credits are issued. Projects may elect to begin the permanence period prior to the end of their maximum allowable crediting period by notifying the Reserve in writing prior to their next reporting deadline. This monitoring can take different forms depending on the terms of the conservation easement which binds the project area. In any case, monitoring must continue through the permanence period to confirm that no reversals have occurred, and the results of this monitoring must be reported to the Reserve periodically. There are two categories of monitoring scenarios: projects may either be monitored as part of their easement monitoring activities, or they may be monitored specifically for the carbon project. In both cases, the required periodic monitoring reports shall, at a minimum, contain the following:

[86] A template monitoring report is available at: http://www.climateactionreserve.org/how/program/documents/.

- Evidence to support the conclusion that no reversals have occurred on the project area since the previous reported time period
- Information related to ongoing activities on the site, including grazing
- Updated information related to ownership of the property, the easement, and the rights to the soil carbon

In certain cases (see Section 7.5.1) these reports are not required to be verified, but in all cases they must be reviewed and approved by the Reserve in order for the terms of the PIA to be satisfied. Project emissions are not quantified during the permanence period. If a reversal is identified, it must be reported to the Reserve and the guidance in Section 5.4 regarding compensation for reversals shall apply.

7.5.1 Monitoring through Easement Activities

If a project area is subject to the terms of a Qualified Conservation Easement (Section 3.5.1) which includes provisions for ongoing monitoring and specific mechanisms for enforcement, such monitoring activities may be considered sufficient for the purposes of this protocol. The Project Owner must submit a monitoring report at least every six years (i.e., this report is due no later than 72 months after the end date of the previous verification or monitoring period, whichever is relevant). The Reserve maintains the right to determine whether the terms of a conservation easement are sufficient to meet the requirements of this section. An easement may be amended at any time to meet these requirements, subject to approval by the Reserve. If the monitoring is not carried out according to the terms of the easement or the monitoring reports are not received by the Reserve, the Project Owner may be in breach of the PIA.

7.5.2 Monitoring for Carbon Separately

If the conservation easement does not contain monitoring and enforcement terms that satisfy Section 7.5.1, the Project Owner must continue monitoring and reporting activities through other means. Projects must prepare and submit a monitoring report to the Reserve at least every 3 years (i.e., this report is due no later than 36 months after the end date of the previous verification or monitoring period, whichever is relevant). These monitoring reports shall be verified at least every fifteen years, although verification may be more frequent. The verification deadlines described in Section 7.4 shall apply.

7.6 Joint Reporting of Project Cooperatives

Project cooperatives carry out a certain amount of joint effort for reporting. While the quantification section shall be applied to each project independently, the results may be collected and reported together to the Reserve by the Cooperative Developer. Reports and documentation may be combined for efficiency, but it must be possible to trace the evidence for the emission reductions from each individual project.

In the management of a cooperative, certain documents are required to be submitted for each individual project, while certain other documents may be submitted once for the entire cooperative. Table 7.2 details which documents belong to which category. The Cooperative Developer shall submit all documentation through their Reserve account. Once the verification report is registered, CRTs shall be issued to the Project Owner account associated with each project in the cooperative.

Table 7.2. Document Management for Project Cooperatives

May Apply to the Cooperative	Must be Submitted for Each Individual Project[87]
▪ Cooperative Submittal form ▪ Verification Report ▪ Verification Statement	▪ Property ownership documentation ▪ Attestation of Title form ▪ Attestation of Voluntary Implementation form ▪ Attestation of Regulatory Compliance form ▪ Project maps

7.6.1 Cooperative Verification Cycle

The verification period for the entire cooperative must end on the same date, unless a project reaches the end of its crediting period during the verification period. In that case, it is acceptable for that project to end reporting prior to the end of the cooperative's verification period. However, during a project's first verification as a member of a cooperative, it may begin reporting at a date that is different from other projects in the cooperative. It is likely that each project in a cooperative has a different start date, and thus during the initial verification for a cooperative each project begins reporting on a different date. The initial verification period shall cover a single reporting period, and the initial reporting period may be up to 24 months in length. Although the individual projects begin their reporting periods on different dates, they shall all end on the same date, such that subsequent verifications of the cooperative will cover the same length of time for every project. When a project joins a cooperative that has already undergone verification, that project's next reporting period must not begin prior to the end of the cooperative's previous verification period, but it may begin at a date that is later than the beginning of the cooperative's next reporting period. Table 7.3 describes various cooperative scenarios and the resultant outcomes for their respective verification cycles.

If an individual project within a cooperative is unable to meet the requirements of this protocol for one or more reporting periods, that project may report zero credits for that time period and continue to be verified as part of the cooperative. For reporting periods where a project claims zero credits, the verifier shall confirm that project emissions were not greater than baseline emissions, and that no reversals occurred. Additional guidance regarding Zero-Credit Reporting Periods can be found in the Reserve Program Manual.[88]

Table 7.3. Example Cooperative Verification Scenarios

Example Scenario	Resulting Verification Cycle
1. Cooperative X contains two projects: Project A has a start date of 1/1/15 and Project B has a start date of 7/22/15.	The initial verification period for the cooperative would cover 1/1/15 – 12/31/16. Project A would report for the entire period, while Project B would report only for 7/22/15 – 12/31/16.
2. Project C wishes to join Cooperative X. Project C has a start date of 5/9/17.	The next reporting period for the cooperative is 1/1/17 – 12/31/17. The first reporting period for Project C would be 5/9/17 – 12/31/17.

[87] These documents for individual projects may be electronically combined into a single PDF (e.g., one digital file may contain the individual Attestation of Title forms for every project in the cooperative).
[88] Available at: http://www.climateactionreserve.org/how/program/program-manual/.

Example Scenario	Resulting Verification Cycle
3. Project D wishes to join Cooperative X. Project D has a start date of 1/1/16 and has not yet gone through verification.	There are two options: *Option i*: The project may undergo verification as a standalone project for the period 1/1/16 – 12/31/16, then subsequently join the cooperative for future reporting. *Option ii*: The project may join the cooperative immediately, taking a Zero-Credit Reporting Period for 1/1/16 – 12/31/16, and begin reporting on 1/1/17 with the cooperative's next verification period.
4. Project E wishes to transfer into Cooperative X from another, different cooperative, which has already undergone verification. The last verification period for Project E ended on 6/30/16.	There are two options: *Option i*: The project may undergo verification as a standalone project for the period 7/1/16 – 12/31/16, then subsequently join the cooperative for future reporting. *Option ii*: The project may join the cooperative immediately, taking a Zero-Credit Reporting Period for 7/1/16 – 12/31/16, and begin reporting on 1/1/17 with the cooperative's next verification period.

8 Verification Guidance

This section provides verification bodies with guidance on verifying GHG emission reductions associated with the project activity. This verification guidance supplements the Reserve's Verification Program Manual and describes verification activities specifically related to grassland projects.

Verification bodies trained to verify grassland projects must be familiar with the following documents:

- Climate Action Reserve Program Manual
- Climate Action Reserve Verification Program Manual
- Climate Action Reserve Grassland Project Protocol

The Reserve's Program Manual, Verification Program Manual, and project protocols are designed to be compatible with each other and are available on the Reserve's website at http://www.climateactionreserve.org.

Only ANSI-accredited verification bodies trained by the Reserve for this project type are eligible to verify grassland project reports. Verification bodies approved under other project protocol types are not permitted to verify grassland projects.[89]

8.1 Joint Verification of Project Cooperatives

Projects that participate in a project cooperative are verified together for every verification period. The Cooperative Developer has their own account on the Reserve through which they submit all documentation related to the cooperative. One set of verification documentation shall be submitted for the entire cooperative, but the project-specific attestations must be executed by the Project Owner for each project.

If the verifier cannot reach a positive verification opinion for one or more projects within a cooperative, the verification may still be completed, and emission reductions registered for the projects for which the verifier can reach a positive opinion. However, the verification of the cooperative as a whole cannot be approved by the Reserve unless an opinion is rendered on every project within the cooperative.

8.2 Standard of Verification

The Reserve's standard of verification for grassland projects is the Grassland Project Protocol (this document), the Reserve Program Manual, and the Verification Program Manual. To verify a grassland project report, verification bodies apply the guidance in the Verification Program Manual and this section of the protocol to the standards described in Sections 2 through 7 of this protocol. Sections 2 through 7 provide eligibility rules, methods to calculate emission reductions, performance monitoring instructions and requirements, and procedures for reporting project information to the Reserve.

[89] Information about verification body accreditation and Reserve project verification training can be found on the Reserve website at http://www.climateactionreserve.org/how/verification/.

8.3 Monitoring Plan

The Monitoring Plan serves as the basis for verification bodies to confirm that the monitoring and reporting requirements in Section 6 and Section 7 have been met, and that consistent, rigorous monitoring and record keeping are ongoing at the project site. Verification bodies shall confirm that the Monitoring Plan covers all aspects of monitoring and reporting contained in this protocol and specifies how data for all relevant parameters in Table 6.1 are collected and recorded.

8.4 Verifying Project Eligibility

Verification bodies must affirm a grassland project's eligibility according to the rules described in this protocol. The table below outlines the eligibility criteria for grassland projects. This table does not present all criteria for determining eligibility comprehensively; verification bodies must also look to Section 3 and the verification items list in Table 8.2.

Table 8.1. Summary of Eligibility Criteria for a Grassland Project

Eligibility Rule	Eligibility Criteria	Frequency of Rule Application
Start Date	Projects must be submitted for listing no more than 6 months after the project start date, unless the project was submitted for listing prior to July 22, 2016	Once during first verification
Start Date	Recordation of a conservation easement, submittal of the project to the Reserve, transfer of the project area to Federal Government ownership, or execution of a notarized contract	Once during first verification
Location	Conterminous United States and tribal areas	Once during first verification
Location	Project strata must have a positive baseline emission factor for soil organic carbon during the reporting period	Every verification
Performance Standard	Project county must pass the financial threshold at the time of project submittal	Once during first verification
Performance Standard	Project area must pass the suitability threshold	Once during first verification
Legal Requirement Test	Signed Attestation of Voluntary Implementation form and monitoring procedures for ascertaining and demonstrating that the project passes the legal requirement test	Every verification
Credit and Payment Stacking	Projects must meet credit and payment stacking requirements and disclose all credits or payments received in relation to the project area	Every verification
Regulatory Compliance Test	Signed Attestation of Regulatory Compliance form and disclosure of all non-compliance events to verifier; project must be in material compliance with all applicable laws	Every verification
Project Implementation Agreement	The Project Owner must execute a PIA with the Reserve prior to the initial registration, and sign an amended PIA prior to each subsequent registration	Every verification

8.5 Core Verification Activities

The Grassland Project Protocol provides explicit requirements and guidance for quantifying the GHG reductions associated with the avoided conversion of grasslands to croplands. The Verification Program Manual describes the core verification activities that shall be performed by verification bodies for all project verifications. They are summarized below in the context of a grassland project, but verification bodies must also follow the general guidance in the Verification Program Manual.

Verification is a risk assessment and data sampling effort designed to ensure that the risk of reporting error is assessed and addressed through appropriate sampling, testing, and review. The three core verification activities are:

1. Identifying emission sources, sinks, and reservoirs (SSRs)
2. Reviewing GHG management systems and estimation methodologies
3. Verifying emission reduction estimates

Identifying emission sources, sinks, and reservoirs
The verification body reviews for completeness the sources, sinks, and reservoirs identified for a project, based on the guidance in Section 4.

Reviewing GHG management systems and estimation methodologies
The verification body reviews and assesses the appropriateness of the methodologies and management systems that the grassland Project Owner uses to gather data and calculate baseline and project emissions, based on the guidance in Sections 5 and 6.

Verifying emission reduction estimates
The verification body further investigates areas that have the greatest potential for material misstatements and then confirms whether or not material misstatements have occurred. This may involve site visits to the project area (or areas if verifying a project cooperative) to ensure the activities on the ground correspond to and are consistent with data provided to the verification body. In addition, the verification body recalculates a representative sample of the performance or emissions data for comparison with data reported by the Project Owner in order to double-check the calculations of GHG emission reductions.

8.5.1 Site Visits

Site visits during verification are strongly recommended, but are not mandatory for grassland projects. However, there is risk associated with a project that has never been visited for the purposes of a third-party verification. This risk is related to the lack of direct, physical inspection of the project area and personal, face-to-face interaction with the project participants, which are valuable components of typical offset project verification activities. The Reserve believes that this risk is low enough in the case of grassland projects that the site visit during verification has been made optional. However, an additional buffer pool contribution must be made to account for the increased risk for those projects which forego a site visit verification. Section 5.4.3 details how this contribution is determined. Although the site visit is optional, it may be carried out at the discretion of the Project Owner or the verifier.

When a site visit is carried out for the verification of a grassland project, the site visit may occur during the verification period or after its conclusion. During this visit the verifier confirms the eligibility of the existing land use, assess the accuracy of the project maps, assess the sources of project emissions, and assess the management and recordkeeping related to the project.

8.5.2 Desk Review Verification

For verifications that do not include a site visit, the verification body must follow the same standards and procedures, but is not required to physically visit the project site. Desk review verifications must achieve the same standard of reasonable assurance.

8.6 Grassland Verification Items

The following tables provide lists of items that a verification body needs to address while verifying a grassland project. The tables include references to the section in the protocol where requirements are further specified. The table also identifies items for which a verification body is expected to apply professional judgment during the verification process. Verification bodies are expected to use their professional judgment to confirm that protocol requirements have been met in instances where the protocol does not provide (sufficiently) prescriptive guidance. For more information on the Reserve's verification process and professional judgment, please see the Verification Program Manual.

Note: These tables shall not be viewed as a comprehensive list or plan for verification activities, but rather guidance on areas specific to grassland projects that must be addressed during verification.

8.6.1 Project Eligibility and CRT Issuance

Table 8.2 lists the criteria for reasonable assurance with respect to eligibility and CRT issuance for grassland projects. These requirements determine if a project is eligible to register with the Reserve and/or have CRTs issued for the reporting period. If any requirement is not met, either the project may be determined ineligible or the GHG reductions from the reporting period (or subset of the reporting period) may be ineligible for issuance of CRTs, as specified in Sections 2, 3, and 6.

Table 8.2. Eligibility Verification Items

Protocol Section	Eligibility Qualification Item	Apply Professional Judgment?
2.2	Verify that the project meets the definition of a grassland project	No
2.2.1	Verify that the project area has been correctly delineated on a map (or maps) that meets the requirements of the protocol	No
2.3	Verify ownership of the GHG reductions by reviewing Attestation of Title and accompanying documentation	No
2.3	Verify the project and/or cooperative structure is appropriate	No
3.2	Verify project start date	No
3.2	Verify accuracy of project start date based on documentation	Yes
3.2	Verify that the project has documented and implemented a Monitoring Plan	No
3.3, 3.4	Verify that the entire reporting period is within the crediting period for the project	No
3.3.1	Verify that the project meets the performance standard test	No
3.3.2	Confirm execution of the Attestation of Voluntary Implementation form to demonstrate eligibility under the legal requirement test	No

Protocol Section	Eligibility Qualification Item	Apply Professional Judgment?
3.3.2	Verify that the project Monitoring Plan contains a mechanism for ascertaining and demonstrating that the project passes the legal requirement test at all times	No
3.3.3	Confirm that disclosure has been made of any other credits or payments received in relation to the project area, and that these conform to the requirements of the protocol	No
3.5.1	Confirm that the Project Owner has executed a PIA with the Reserve	No
3.6	Verify that the project activities comply with applicable laws by reviewing any instances of non-compliance provided by the Project Owner and performing a risk-based assessment to confirm the statements made by the Project Owner in the Attestation of Regulatory Compliance form	Yes
6	Verify that monitoring meets the requirements of the protocol. If it does not, verify that a variance has been approved for monitoring variations	No

8.6.2 Quantification

Table 8.3 lists the items that verification bodies shall include in their risk assessment and recalculation of the project's GHG emission reductions. These quantification items inform any determination as to whether there are material and/or immaterial misstatements in the project's GHG emission reduction calculations. If there are material misstatements, the calculations must be revised before CRTs are issued.

Table 8.3. Quantification Verification Items

Protocol Section	Quantification Item	Apply Professional Judgment?
4	Verify that all SSRs in the GHG Assessment Boundary are accounted for (unless optional)	No
5	Verify that the emission factors are all correctly selected for the relevant parameters, both for baseline emissions and project emissions	No
5.1	Verify that the stratification procedures were carried out properly	Yes
5.2	Verify that the baseline emissions are properly aggregated (and pro-rated, if applicable)	No
5.2.1	Verify that the project employed the appropriate discount factors	No
5.3	Verify that the project emissions were calculated according to the protocol with the appropriate data	No
5.3.1	Verify that the Project Owner correctly monitored and quantified fires	No
5.3.2	Verify that the Project Owner correctly monitored, quantified, and aggregated fossil fuel use	Yes
5.3.3	Verify that the Project Owner correctly monitored and quantified fertilizer use	No
5.3.4	Verify that the Project Owner correctly monitored and quantified grazing activities	No
5.4	Verify that no reversals have occurred and that the correct contribution was calculated for the buffer pool	No

8.6.3 Risk Assessment

Verification bodies shall review the following items in Table 8.4 to guide and prioritize their assessment of data used in determining eligibility and quantifying GHG emission reductions.

Table 8.4. Risk Assessment Verification Items

Protocol Section	Item that Informs Risk Assessment	Apply Professional Judgment?
6	Verify that the project Monitoring Plan is sufficiently rigorous to support the requirements of the protocol and proper operation of the project	Yes
6	Verify that appropriate monitoring practices are in place to meet the requirements of the protocol	No
6	Verify that the individual or team responsible for managing and reporting project activities are qualified to perform this function	Yes
6	Verify that appropriate training was provided to personnel assigned to greenhouse gas reporting duties	Yes
6	Verify that all contractors are qualified for managing and reporting greenhouse gas emissions if relied upon by the Project Owner. Verify that there is internal oversight to assure the quality of the contractor's work	Yes
7.3	Verify that all required records have been retained by the Project Owner	No

8.6.4 Completing Verification

The Verification Program Manual provides detailed information and instructions for verification bodies to finalize the verification process. It describes completing a Verification Report, preparing a Verification Statement, submitting the necessary documents to the Reserve, and notifying the Reserve of the project's verified status.

9 Glossary of Terms

Accredited verifier	A verification firm approved by the Climate Action Reserve to provide verification services for Project Owners.
Additionality	Project activities that are above and beyond "business as usual" operation, exceed the baseline characterization, and are not mandated by regulation.
Anthropogenic emissions	GHG emissions resultant from human activity that are considered to be an unnatural component of the Carbon Cycle (i.e., fossil fuel destruction, de-forestation, etc.).
Biogenic CO_2 emissions	CO_2 emissions resulting from the destruction and/or aerobic decomposition of organic matter. Biogenic emissions are considered to be a natural part of the Carbon Cycle, as opposed to anthropogenic emissions.
Carbon rights	Legal ownership of carbon stored in pools located within the project area. Carbon rights may be separate from GHG reduction rights (defined below).
Carbon dioxide (CO_2)	The most common of the six primary greenhouse gases, consisting of a single carbon atom and two oxygen atoms.
CO_2 equivalent (CO_2e)	The quantity of a given GHG multiplied by its total global warming potential. This is the standard unit for comparing the degree of warming which can be caused by different GHGs.
Cooperative Developer	The entity responsible for management of a project cooperative. The Cooperative Developer may or may not be one of the Project Owners participating in the project cooperative.
Crediting period	The period of time over which CRTs may be quantified and registered under this protocol. For a grassland project, the crediting period may be a maximum of 50 years.
Cropland	Land whose management is primarily conducted through "cultural" treatments, such as human and/or mechanical labor, fertilization, irrigation, tillage, seeding, and/or planting. While cropland may include seasonal livestock grazing, at least a portion of the year it is specifically given over to cultivation of a crop which is intended to be harvested for off-site consumption.
Direct emissions	GHG emissions from sources that are owned or controlled by the reporting entity.
Emission factor (EF)	A unique value for determining an amount of a GHG emitted for a given quantity of activity data (e.g., metric tons of carbon dioxide emitted per barrel of fossil fuel burned).
Fossil fuel	A fuel, such as coal, oil, and natural gas, produced by the decomposition of ancient (fossilized) plants and animals.

Grassland	An area of land dominated by native or introduced grass species with little to no tree canopy. Other plant species may include legumes, forbs, and other non-woody vegetation. Tree canopy may not exceed 10% of the land area on a per-acre basis. For the purpose of this protocol, grassland may include managed rangeland and/or pastureland.
Greenhouse gas (GHG)	Carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), sulfur hexafluoride (SF_6), hydrofluorocarbons (HFCs), or perfluorocarbons (PFCs).
GHG reduction rights	Legal ownership of the GHG emission reductions resulting from avoided grassland conversion project activities on the project area during the reporting period. GHG reduction rights may be separate from carbon rights (defined above).
Grassland Owner	An individual or entity which has a right of ownership over a portion or all of the project area, or an ownership right whose exercise could reasonably be expected to impact soil carbon storage on a portion or all of the project area.
Grazing season	The period of time bounded by the first and last days of livestock grazing during the reporting period.
GHG reservoir	A physical unit or component of the biosphere, geosphere, or hydrosphere with the capability to store or accumulate a GHG that has been removed from the atmosphere by a GHG sink or a GHG captured from a GHG source.
GHG sink	A physical unit or process that removes GHG from the atmosphere.
GHG source	A physical unit or process that releases GHG into the atmosphere.
Global Warming Potential (GWP)	The ratio of radiative forcing (degree of warming to the atmosphere) that would result from the emission of one unit of a given GHG compared to one unit of CO_2.
Indirect emissions	Reductions in GHG emissions that occur at a location other than where the reduction activity is implemented, and/or at sources not owned or controlled by project participants.
Metric ton (t, tonne)	A common international measurement for the quantity of GHG emissions, equivalent to about 2204.623 pounds or 1.102 short tons.
Methane (CH_4)	A potent GHG with a GWP of 21, consisting of a single carbon atom and four hydrogen atoms.
MMBtu	One million British thermal units.
Mobile combustion	Emissions from the transportation of employees, materials, products, and waste resulting from the combustion of fuels in company owned or controlled mobile combustion sources (e.g., cars, trucks, tractors, dozers, etc.).
Non-reversible emission reductions	An emission reduction is not considered reversible if it represents the destruction or avoided emission of a GHG which does not rely on storage within a carbon pool. For example, the avoided emissions of N_2O due to cultivation activities are considered non-reversible.

Pastureland	An area of grassland which is managed through livestock grazing as well as other “cultural” treatments, such as human and/or mechanical labor, fertilization, irrigation, and/or seeding. For the purpose of this protocol, pastureland may not involve any level of tillage.
Permanence period	The period of time following the crediting period during which the Project Owner must continue monitoring, reporting, and verification activities under this protocol. The permanence period for a grassland project is 100 years following the last issuance of CRTs related to reversible emission reductions.
Project area	The area defined by the physical boundaries of the project activities. The project area only contains land which meets the eligibility requirements of this protocol.
Project baseline	A “business as usual” GHG emission assessment against which GHG emission reductions from a specific GHG reduction activity are measured.
Project Owner	An entity that has title to the emission reduction credits issued under this protocol and undertakes a GHG project, as identified in Section 2.2 of this protocol. The Project Owner may also be the Cooperative Developer and/or a Grassland Owner.
Rangeland	An area of grassland which is managed principally through the use of livestock grazing. For the purpose of this protocol, rangeland must meet the definition of grassland.
Reporting period	The length of time over which GHG emission reductions from project activities are quantified. Under this protocol, the reporting period can be no more than 12 months.
Reversible emission reductions	An emission reduction is considered reversible if it represents an avoided emission or enhanced sequestration of carbon which must be stored in a carbon pool. For example, the avoided emissions of soil organic carbon due to cultivation activities are considered reversible, and the carbon must be permanently maintained through conservation of the project area.
Shrub	A woody perennial plant, generally more than 1.5 feet and less than 16.5 feet in height at maturity and without a definite crown (24). Shrubs will usually have multiple stems no more than 3 inches in diameter (23).
Tree	A woody perennial plant, typically large and with a well-defined stem or stems carrying a more or less definite crown with the capacity to attain a minimum diameter at breast height of 5 inches and a minimum height of 15 feet with no branches within three feet from the ground at maturity (24).
Verification	The process used to ensure that a given participant’s GHG emissions or emission reductions have met the minimum quality standard and complied with the Reserve’s procedures and protocols for calculating and reporting GHG emissions and emission reductions.
Verification body	A Reserve-approved firm that is able to render a verification opinion and provide verification services for operators subject to reporting under this protocol.
Verification period	The length of time over which GHG emission reductions from project activities are verified. Under this protocol, the verification period can cover up to six reporting periods during the crediting period, and up to ten reporting periods during the permanence period.

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Appendix A Development of the Performance Standard

The Reserve assesses the additionality of projects through application of a performance standard test and a legal requirement test. The purpose of a performance standard is to establish a standard of performance applicable to all grassland projects that serves as a proxy for a significant threat of conversion of the project area to crop cultivation. If this standard is met or exceeded by the Project Owner, the project satisfies the criterion of "additionality."[90]

A.1 Components of the Performance Standard Test

The Grassland Project Protocol performance standard test has two components:

1. Financial threshold
2. Suitability threshold

The intent of this two-part test is to create a standardized proxy for the complex decision-making process that leads to land use change. A project-specific approach would allow for the evaluation of all barriers to the project activity at the project site, but it would be fraught with subjectivity and uncertainty due to the counterfactual nature of the baseline scenario. Moreover, project-specific determinations of additionality tend to be very expensive and labor-intensive, thus rendering relatively low-volume projects, such as grassland projects, to be infeasible. While each individual component of the performance standard test would not, on its own, be a rigorous test of the additionality of the project, the Reserve believes that, taken as a whole with the other requirements for eligibility (e.g., location, legal surplus), the performance standard test does achieve such an outcome.

In addition to the two components of the performance standard test, projects are subject to a location-based emission reductions threshold, discussed in Section 3.1. Although this eligibility screen is not part of the performance standard test, it works in conjunction with the performance standard test to identify eligible projects.

A.1.1 Location-Based Emission Reductions Threshold

This component of the eligibility screening is quantitative. Its premise is that projects should only be eligible if, based on the quantification methodology used by this protocol, the project will generate creditable emission reductions. The main focus of this protocol is the avoided emission and permanent protection of soil organic carbon (SOC). Thus, SOC is the focus of the emission reductions threshold.

For the purposes of this protocol, the U.S. has been stratified in order to enable the development of baseline and project emissions estimates that correspond to local soil conditions, climatic conditions, starting condition, and agricultural practices. A stratum represents a unique combination of these variables. All baseline modeling was performed at the stratum level, enabling the resulting emissions estimates to represent relatively fine distinctions in the primary drivers of variation in emissions. In total, this protocol established emissions estimates for 1,002 total strata within the U.S. By stratifying the country in this manner, the emissions estimates used in this protocol provide greater local accuracy and representation than would emission estimates generated at a national scale or with fewer variables. These variables act as filters that each brings greater specificity to the emissions estimates by more

[90] See the Climate Action Reserve's Program Manual for further discussion of the Reserve's general approach to determining additionality: http://www.climateactionreserve.org/how/program/program-manual/.

precisely estimating the conditions of the project. Land is first broken down by climate and geography, then further delineated by the major soil type and texture, and finally evaluated based on the previous land use.

The following variables were used to stratify the U.S:

- Geography and associated climate
- Soil texture
- Previous land use

A.1.1.1 Geography and Associated Climate

The first level of stratification used in this protocol delineates land based on its geography and associated climate, due to these factors important influence over carbon pools and sources in both natural and managed ecosystems (8). Regional climate and geographic conditions are determined through the use of Major Land Resource Area (MLRA) designations, as defined by the U.S. Department of Agriculture, Natural Resources Conservation Services (9). These designations are used for a variety of policy and planning decisions, as they represent information about land suitability for farming and other purposes. As such, they constitute a land area that has similar physical and climatic characteristics. In total, there are approximately 280 MLRAs in the U.S. However, some of these MLRAs contain very little cropland or grassland feasible for conversion. Appendix B provides an overview of the methodology used to screen out certain MLRAs based on the absence of significant areas of grassland or cropland, and constraints on data availability and modeling confidence.

A.1.1.2 Soil Texture

Soil texture has a significant impact on land productivity and carbon dynamics through influences on soil fertility and water balance and on soil organic matter stabilization processes (10). Accordingly, the second level of stratification requires differentiating by soil texture. While successively finer delineations of soil type and texture would yield greater precision, this protocol limits the stratification of soils into three major classes of surface soil texture as defined by USDA. These are:

- Coarse
- Medium
- Fine

By adding soil texture to the stratification, the quantification is improved in two ways. First, the texture itself plays a considerable role in the carbon dynamics being modeled (27), allowing more refined and representative results. Second, defining the stratum with the soil texture limits the cropping systems and management practices that are modeled to those suitable to these soils by evaluating only those systems seen on other similar soils within the MLRA. Use of soil texture therefore gives greater precision to the crop system inputs and resulting model accuracy.

A.1.1.3 Previous Land Use

Initial carbon pools at project commencement will be significantly influenced by previous land uses. Additionally, soil quality at project initiation influences nutrient inputs and farming practices in the baseline scenario. Because this protocol allows for the avoided conversion of grasslands with somewhat varied histories, the third level of stratification requires grasslands to be delimited by the duration of time it has been in a grassland state. This protocol defines the following two categories for grasslands:

- Greater than 10, but less than 30 years continuous grassland or pastureland
- Greater than 30 years continuous, long-term permanent grassland or pastureland

To develop this threshold, the baseline scenario was modeled for a period of 50 years for each individual stratum. The outputs from the models were averaged over 10 year periods to smooth out any inter-annual variability and stochasticity inherent in the modeling. Due to the specific characteristics of the individual strata and the common management practices in those areas, some strata exhibit SOC loss after conversion to cropland, some do not, and some show consistent SOC gains. A stratum may only be eligible if we have an emission factor that shows a baseline loss of SOC for the first 10 year emission factor period. If the stratum shows baseline SOC gains for an emission factor period, then the project crediting period will end prior to that emission factor period. Table A.1 and Figure A.1 show a summary of the outcome of this test.

Table A.1. Summary of Strata Eligibility Based on Emission Reduction Potential

Categories	Number of Strata in Each Category
Total possible strata	1,668
Strata with no data for modeling	667
Strata with no emission reductions in first 10 years	331
Potentially eligible strata	670

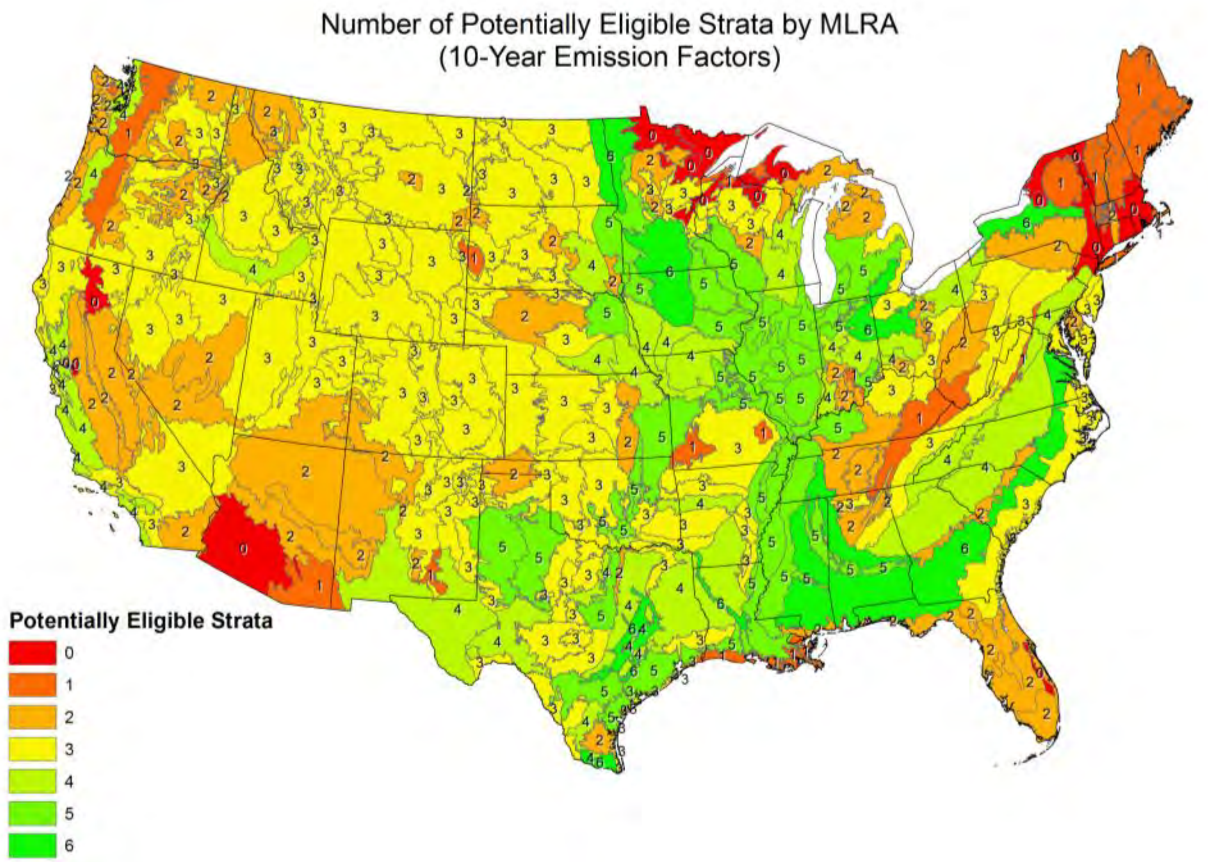

Figure A.1. Potentially Eligible Strata for Each MLRA

A.1.2 Financial Threshold

The first component of the performance standard test is a financial threshold. The concept is that the monetary incentive provided by offsets is needed to counteract the existing financial incentive to convert grassland to cropland. The incentive to convert to cropland is thus viewed as a barrier to the project. As a proxy for this financial incentive, the Reserve uses the concept of the "cropland premium." The cropland premium for a county value of the cash rent rate for cropland compared to the cash rent rate for pastureland. In other words, the cropland premium represents the increased value (either as a percentage or in absolute dollars per acre) of land that is converted from pasture to crop production.

This approach is also utilized by avoided conversion project type in the Reserve Forest Project Protocol,[91] which requires the Project Owner to obtain a certified real estate appraisal of the project area to identify the land's value as a forest (project scenario) and as the converted land use (baseline scenario). The percentage difference between these two must exceed 40% for eligibility and must exceed 80% to avoid the application of a discount, which is calculated on a sliding scale between the two thresholds.[92] The discount represents the uncertainty of the baseline conversion and recognizes that the threshold for the decision to convert will vary between landowners.

[91] Climate Action Reserve, Forest Project Protocol Version 3.3 (November 15, 2012). Section 3.1.2.3.
[92] Climate Action Reserve, Forest Project Protocol Version 3.3 (November 15, 2012). Equation 6.14.

A.1.2.1 Calculating the Cropland Premium

The rent rate data are collected through the annual cash rent survey of the USDA National Agricultural Statistics Service (NASS).[93] This dataset is robust and published on a regular, annual schedule. The cash rent survey provides a value, in dollars per acre, of the cash rent paid for non-irrigated cropland, irrigated cropland, and pastureland. The non-irrigated cropland rent rate is used as a proxy for the value of cropland. The pastureland rent rate is used as a proxy for the value of grassland. Cropland premiums were calculated by subtracting the average pastureland rent rate from the average non-irrigated cropland rent rates, then dividing by the average pastureland rent rate.

In order to smooth out inter-annual fluctuations and account for years with missing data, the financial threshold is based on an average of the cropland premium for the previous three years. If there are too few respondents in a particular county to ensure anonymity of the reported data, those counties are combined and averaged together by the NASS at the level of the Agricultural Statistics District (ASD) and identified in the data as “Other (Combined) Counties.” Thus, where a county did not have a value listed for a particular rent category for a particular year, the average for the ASD for that year was used. If there was no ASD average reported, the value was left out. When averaging the rent values over the three year period, only years with reported values were considered (i.e., “no value” was not considered to equal zero). For projects with start dates during the calendar year 2015, rent rate data from 2012-2014 were used.

A.1.2.2 Setting the Threshold

Once the cropland premiums were determined, a policy decision was made as to where the threshold should be set. There are several options for how to consider the cropland premium as a proxy for the financial incentive to convert the project area. There were also several other decisions that ultimately influenced the threshold, such as the most appropriate geographic level of analysis (county, ASD, state, region) and the particular metric for the cropland premium (absolute $/acre or percent difference).

As the rent rate data are available at the county level, the Reserve chose to use this level for the analysis. Following the approach used in the Forest Project Protocol, the Reserve elected to continue to apply the financial threshold as a percent difference, rather than a dollar value, which limits the impact of other variables that affect land value. This approach is also used in the Avoided Conversion of Grasslands and Shrublands (ACoGS) methodology adopted by the American Carbon Registry, although that methodology does not rely on a standardized assessment of land value.

The Forest Project Protocol sets a threshold of 40% premium for eligibility, and 80% premium for undiscounted eligibility. The ACR ACoGS methodology sets a threshold of 40% premium for eligibility and 100% premium for undiscounted eligibility. The Reserve has elected to adopt the thresholds described in the ACoGS methodology. Cropland premiums between these two values are subject to a discount on a sliding scale, following the guidance in Equation 5.6.

Although the threshold will be applied to new rent rate data each year, the thresholds themselves will not change unless the Reserve carries out a new analysis and issues a new version of this protocol.

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[93] Information available at: http://www.nass.usda.gov/Surveys/Guide_to_NASS_Surveys/Cash_Rents_by_County/index.asp. Accessed October 13, 2014.

A.1.2.3 List of Eligible Counties

Once the threshold was determined, it was then applied to the rent rate data to determine the list of eligible counties. Following the procedures above, the Reserve determined the average cropland premiums for the most recent three year period (2012-2014). The financial thresholds were then applied to these data (Figure A.2). This exercise will be conducted as new rent rate data become available. For counties which are identified as having no data, a Project Owner may request that the Reserve examine the data for surrounding counties and determine whether the county may be considered eligible (and the appropriate value for DF_{conv}, if applicable). The revised list of eligible counties, along with their value for DF_{conv}, if applicable, will be published and be effective for new projects submitted during the following year. The current tables, as well as any future updates, are available by individual request (email to policy@climateactionreserve.org or call (213) 891-1444) or for download at: http://www.climateactionreserve.org/how/protocols/grassland/.

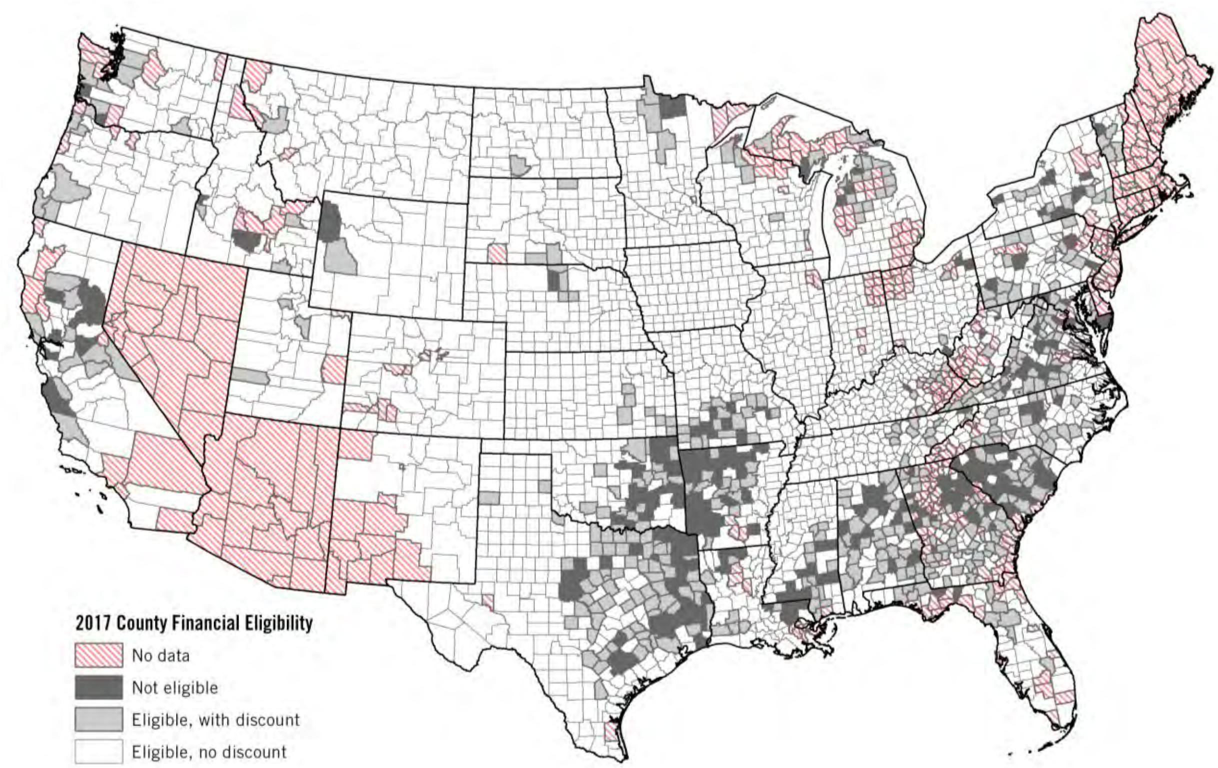

Figure A.2. Eligibility of Counties Based on the Financial Threshold for Additionality

A.1.3 Suitability Threshold

Projects should only be considered additional if the project area is actually suitable for conversion to crop cultivation. Otherwise, the baseline scenario is invalid, and the project area is not actually under threat of conversion to cropland. This is the premise behind the second component of the performance standard test: the suitability threshold. There are numerous parameters (slope, drainage, rockiness, etc.) that contribute to the overall suitability of a parcel for crop cultivation. The Natural Resources Conservation Service (NRCS) Land Capability Classification (LCC) system is widely used to simplify the description of land areas in regards to its suitability for cultivation (3). The Reserve has chosen to use the NRCS LCC system to assess the suitability threshold for grassland projects.

There are eight LCC classes, numbered I through VIII:

I. Soils have few limitations that restrict their use. (no subclasses)
II. Soils have some limitations that reduce the choice of plants or require moderate conservation practices. (all subclasses)
III. Soils have severe limitations that reduce the choice of plants or require special conservation practices or both. (all subclasses)
IV. Soils have very severe limitations that restrict the choice of plants, require very careful management, or both. (all subclasses)
V. Soils have little or no erosion hazard but have other limitations impractical to remove that limit their use largely to pasture, range, woodland, or wildlife food and cover. (subclasses w, s, c)
VI. Soils have severe limitations that make them generally unsuited to cultivation and limit their use largely to pasture or range, woodland, or wildlife food and cover. (all subclasses)
VII. Soils have very severe limitations that make them unsuited to cultivation and that restrict their use largely to grazing, woodland, or wildlife. (all subclasses)
VIII. Soils and landforms have limitations that preclude their use for commercial plant production and restrict their use to recreation, wildlife, or water supply or to esthetic purposes. (all subclasses)

In addition, there are four subclasses, indicated by letter:

(e) Erosion
(w) Excess wetness
(s) Problems in the rooting zone
(c) Climatic limitations

Crop cultivation is generally not recommended for land classified above Class IV (3). We have received stakeholder feedback that would push this threshold in both directions, some saying that no land above Class III should be cultivated, and others saying that they have seen Class V and VI land being actively converted. Recent research has supported this conclusion (3). The Reserve has chosen to rely on the general recommendation that classes above IV are not suitable for cultivation, while recognizing that land characteristics tend to be more heterogeneous than legal boundaries by allowing for small components of the project area to be Class V or VI.

To determine the appropriate minimum threshold for NICC I-IV soils as a percentage of the total project area, the Reserve assessed the NICC for existing, non-irrigated cropland, as well as the NICC for non-irrigated cropland that was identified as being newly-converted. The irrigation data were from the most recent (2012) version of the Moderate Resolution Imaging Spectroradiometer (MODIS) Irrigated Agriculture Dataset for the United States (MIrAD-US).[94] The cultivated lands data used in the assessment, known as the USDA Cultivated Layer, were obtained by request from the USDA NASS[95]; the public CDL data portal, CropScape, only offers the most recent version of the Cultivated Layer. The Cultivated Layer is a 5-year composite of all land that has been identified as cropland. To align with the MIrAD-US data, the 2012 Cultivated Layer (showing cropland from 2008-2012) was used. The data regarding which of these lands were considerednewly-converted croplands were obtained from researchers at the University of Wisconsin (24). These data are also based on the 2008-2012 Cropland Data Layers.

For each state, the data for cultivation, irrigation, MLRA, and soil map unit were combined using ArcMap. The resulting data layer identifies all of this information for each 250m x 250m pixel; thus the resolution of the analysis is 15.44 acres. The tables were then combined into one large table, allowing for assessment of each MLRA, regardless of political boundaries. The area for each MLRA that is cultivated but not irrigated is summed according to its NICC, allowing for a determination of the percentage of non-irrigated cropland in that MLRA which is classified as NICC I-IV. The analysis was also conducted for irrigated lands, using the ICC. For any MLRAs with insufficient data to develop either a NICC or ICC threshold, the default threshold will be 100%. This is a conservative approach given that those MLRAs do not show significant crop cultivation activity. Of course, projects will still have the option for the local, site-specific LCC assessment.

The same analysis was then conducted using only areas of newly-converted cropland (2008-2012). For areas with sufficient amounts of new cropland, the resulting values from the existing cropland and the newly-converted cropland were then averaged together to obtain the default value for the suitability threshold for that MLRA. This approach seeks to recognize that recent conversion trends may be different than historical conversion trends. In many places, the LCC of new cropland is higher than existing cropland (i.e., newly converted cropland may be considered of “marginal” quality for crop cultivation).

A.1.4 Complete Performance Standard Test

While neither of the individual components of this performance standard test (or the eligibility section as a whole) would represent a comprehensive test for additionality on their own, when considered together, along with the eligibility limitations arising from the baseline stratification and modeling, they function to provide a holistic assessment of the threat of conversion of grassland to cropland in different areas of the country.

[94] The MIrAD-US data are available at: http://earlywarning.usgs.gov/USirrigation.
[95] Information regarding the Cropland Data Layer and the Cultivated Layer is available at: https://www.nass.usda.gov/Research_and_Science/Cropland/SARS1a.php.

Appendix B Development of Standardized Parameters and Emission Factors

The approach outlined in this appendix was developed and executed by the Reserve's technical contractor WSP. The team consisted of Tim Kidman and Michael Mondshine at WSP, and Dr. Keith Paustian, Ernest Marx, Mark Easter, Ben Johkne and Stephen Williams at Colorado State University. The effort described here has resulted in a fixed collection of emission factors. The Reserve will seek to replicate this process at a later date in order to generate updated emission factors for AGC projects.

B.1 Introduction

This appendix describes the standardized assumptions used by the Reserve's technical contractor in modeling baseline GHG emissions from the conversion of grasslands to croplands. It also describes the modeling approach used by the Reserve's contractor to estimate the baseline emissions from soil processes, soil organic carbon, below-ground biomass, and fertilizer N_2O emissions using the DAYCENT model and a combination of national data sources. The methodology and standardized baselines are intended to provide accurate estimates of baseline emissions, give certainty over expected project outcomes, minimize project setup and monitoring costs, and reduce verification costs. The resulting emission rates, applied in the protocol as per acre emission factors, preclude the need for project-level modeling by Project Owners.

Modeling was performed using the same build of the DAYCENT model that is used for estimation of the Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2013[96] (U.S. Inventory) compiled by EPA, and which is incorporated in USDA's entity level GHG quantification tool, COMET-Farm[97]. To compute the emissions associated with baseline conversion scenarios, the contractors utilized a DAYCENT model inputs database developed for the U.S. Inventory. The Inventory Database (IDB) was derived from national level soils and weather data sources, the USDA's Natural Resources Inventory (NRI) as well as ancillary data sets on actual agricultural management practices across the U.S. The NRI is a statistically robust stratified sampling design that includes land use and management data since 1979 at ca. 400,000 non-federal cropland and grassland locations.

The DAYCENT model (i.e., daily time-step version of the Century model) simulates cycling of carbon, nitrogen, and other nutrients in cropland, grassland, forest, and savanna ecosystems on a daily time step. This includes CO_2 emissions and uptake resulting from plant production and decomposition processes, and N_2O emissions from the application of synthetic and manure fertilizer, the retention of crop residues and subsequent mineralization, and mineralization of soil organic matter. DAYCENT simulates all processes based on interactions with location-specific environmental conditions, such as soil characteristics and climate.

[96] Available at: http://www.epa.gov/climatechange/Downloads/ghgemissions/US-GHG-Inventory-2014-Main-Text.pdf.
[97] Available at: http://cometfarm.nrel.colostate.edu.

B.2 Conceptual Overview

The approach to baseline determination and baseline modeling relies almost exclusively on geographic, historic, and physical characteristics of project parcels – most of which are publicly available in national geospatial databases – in assigning a baseline and associated emissions for any given project parcel. The methodology does not require project proponents to assert a single baseline cropping system, tillage, or management practice, support that assertion with detailed documentation, or justify why assertions represent reasonable baseline assumptions. Rather, this methodology establishes and dictates a composite baseline for any given parcel based on the practices documented on ecologically and geologically similar parcels using a variety of national databases. The methodology does not establish a single tillage practice, average fertilizer practice or other factors and use that as the baseline to model that single scenario to obtain baseline emission rates. Instead, the methodology acknowledges variability in practice, and the uncertainty associated with predicting future practice by assuming that there is a certain probability that the converted land could be managed in a variety of ways. The modeled management practices were generated based on survey data from land within the same eco-climatic region and soil type as the project parcel, based on the IDB and related data sources defined below.

Through this exercise 154,639 long term grassland points and 162,460 short term grassland points were modeled. The resulting emission rates for each stratum represent a weighted average of the potential practices on the parcel were it to be converted to cropland, with weighting based on the relative prevalence of each practice within the survey data. This approach to baseline determination eliminates subjectivity by standardizing the baseline determination based exclusively on stratification (see Section 5.1).

Similarly, the methodology does not require project proponents to execute complex biogeochemical process models. Instead, the methodology provides composite emission rates derived from these same biogeochemical process models utilizing geographic, soil, and cropping system assumptions representative of the project parcel.

Compared to the alternative in which project proponents would be responsible for asserting and documenting their baseline assumptions, and then conducting modeling themselves, this method has several important advantages, which are outlined in Section B.7.

B.3 Baseline Determination

The baseline for any given project parcel is defined probabilistically as a composite of the likely practices that might occur on that parcel were it to be converted from grassland to cropland.

The stratification regime defined in Section 5.1 of the protocol plays a fundamental role in establishing the range of practices and relative probabilities for baseline practice. Based on two of the three stratification elements – the Major Land Resource Area (MLRA) and the dominant surface soil texture from the Soil Survey Geographic Database (SSURGO) – the U.S. was first broken into individual super-strata (unique combinations of these two variables).[98] By first stratifying by MLRA and surface soil texture, the U.S. is effectively subdivided into land areas based on suitability to certain cropping systems and the practices associated with those systems in those geographies. Because MLRAs are based on agroecological classification, they define areas of similar climate, geomorphology, native vegetation and land management

[98] The third variable, previous land use, will be used later in the modeling of baseline emissions.

systems – all of which are the fundamental drivers of the biogeochemical processes involved in greenhouse gas emissions. Thus MLRAs are well-suited as stratification variables than other land area designations that are politically-based (e.g., states) or defined by a more limited set of criteria (e.g., NRCS Crop Management Zones (CMZ) based on farm management practices). By adding soil texture to the stratification, the quantification is improved in two ways. First, the texture itself plays a considerable role in the carbon dynamics being modeled (27), allowing more refined and representative results. Second, defining the stratum with the soil texture limits the cropping systems and management practices that are modeled to those suitable to these soils by evaluating only those systems seen on other similar soils within the MLRA. Use of soil texture therefore gives greater precision to the crop system inputs and resulting model accuracy.

For each unique super-strata, baseline practices were collected and estimated based on the real-world practices on agricultural land within the same super-stratum, as derived from the IDB, USDA National Resource Inventory (NRI), Economic Research Service Cropping Practice Survey (ERS), National Agricultural Statistics Service (NASS), and Natural Resources Conservation Service (NRCS) (29) (30).[99,100] These resources represent the best available data sources for agricultural practice in the U.S. A brief description of the relevant data sources is included below:

- **Inventory Database (IDB)**: Developed by Colorado State University as input data for the Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2013 (13), the IDB is derived from a variety of data sources including SSURGO, NRI, CTIC, ERS, NASS (described below). The IDB describes typical management practices for distinct regions and soils at MLRA and county scales.
- **Major Land Resource Area (MLRA)**: Agro-ecological classification developed NRCS that defines areas of similar climate, geomorphology, native vegetation, and land management systems across the U.S.
- **Soil Survey Geographic Database (SSURGO):** Developed and managed by NRCS, the SSURGO database contains geographically linked information on soil properties including texture. SSURGO data were collected by the USDA National Cooperative Soil Survey, covering the states, commonwealths and territories of the U.S. It was generated from soil samples and laboratory analysis, and represents the finest resolution soil map data available in the U.S.
- **National Resource Inventory (NRI):** Developed and managed by NRCS, the NRI is a statistical survey of land use and natural resource conditions on non-federal U.S. lands. It provides data on the status, condition, and trends of land, soil, water and related resources. The NRI utilizes established inventory sites for repeated sampling to provide national representation.
- **Conservation Tillage Information Center (CTIC)**: Since 1989, CTIC has conducted annual county-level surveys of tillage practices, by crop. These data are used to estimate probabilities for tillage practices and tillage transitions, for IDB locations within the surveyed counties.
- **Economic Research Service:** Housed within the USDA, ERS gathers a variety of data on crop and livestock practices through the use of its annual Agricultural Resource Management Survey (ARMS). ERS provides both annual and trend data, illustrating

[99] USDA-NASS: https://www.nass.usda.gov/.
[100] USDA-NRCS (2012) *Energy Estimator: Tillage*, available at: http://ecat.sc.egov.usda.gov/.

shifts in agricultural practice. ERS contains data on nutrient management, irrigation practices, and conservation practices.

- **National Agricultural Statistics Service (NASS):** Data on annual county-average crop area and yields from NASS are used as a secondary data source for availability control of model outputs.
- **Natural Resource Conservation Service (NRCS)/Energy Tools:** Data related to the energy inputs required for cropland management, including planting, tillage, fertilization, and harvesting. (http://energytools.sc.egov.usda.gov/)

For each super-stratum combination of MLRA and soil texture, relevant variables about baseline conditions were established using these data sources, with specific variables pulled from each as defined in Table B.1. In many cases, these variables are linked. For example, IDB data are used to establish the various cropping sequences, and then each crop is assigned nitrogen application rate distributions based on regional ERS data. The methodology used to link data and determine practices within regions is based on the methodology used in the U.S. Inventory (13). For further detail on how these datasets are used to set appropriate conditions, please refer to the sections Agriculture and Land Use, Land-Use Change, and Forestry in the U.S. Inventory.

Table B.1. Derivation of Baseline Scenario Input Variables

Baseline Variable	Data Source	Methodology
Tillage practice	IDB, CTIC	Assignment of tillage practices established using CTIC data in each super stratum and associated expansion factors. County-level CTIC data were recalculated at the MLRA level, with practices assigned to simulations through use of NIDB area-weights.
Typical cropping sequence	IDB, NASS	Assignment of each cropping sequence established using IDB data in each super stratum and associated area-weights, based on the cropping sequence from 2000-2007, supplemented by NASS data.
Fertilizer N application	ERS, NASS	Crop-specific N rates assigned based on state-level statistics, subdivided by MLRA, based on the most recent five years period.
Application of other nutrients/organic matter	NRCS	Livestock manure application frequency and rates estimated based on NRCS data and adjusted for county-level estimates of manure availability, based on the most recent five years period.
Irrigation practice	IDB	Irrigated vs. non-irrigated status are specified for each IDB location, based on the most recent five years period. For irrigated land, full irrigation (i.e., no significant water stress) is modeled.
Fuel consumption	NRCS	Energy consumption for each cropland management practice, based on CMZ, tillage practice, and crop.

Table B.2 provides an illustrative overview of some of the crop system data elements that went into the establishment of the composite baseline conditions for any given super-stratum, and a highly simplified example distribution. Based on the cropping systems established from historic data, additional nutrient input data were applied based on ERS and NASS data. In addition to the cropping and management variables extracted from these data sources, the methodology employs IDB area-weights to appropriately weight each practice based on its representativeness across the landscape. IDB area-weights are based on the spatial resolutions of source data, including NRI expansion factors, SSURGO map unit areas, and spatial scales of fertilizer and tillage data. The IDB area-weights indicate the number of acres across the landscape that each IDB location point represents.

The baseline for this example super stratum would be, for example, 20% constructed from data point #1 which is a practice that includes the use of no till on irrigated land, and with a crop rotation of corn, soy, corn, soy, fallow. This is based on the existence of an IDB location with that practice and its area-weight (100) being 20% of the aggregate of IDB area-weights (500) within the super stratum.

Table B.2. Example Crop Systems and Resulting Probabilities in Baseline

IDB Data Point	Tillage Practice	Irrigation Practice	Cropping System	Area-weight	Probability
#1	No Till	Irrigated	Corn, soy, corn, soy, fallow	100	20%
#2	Conservation Till	Not Irrigated	Corn, soy, fallow, wheat, soy	150	30%
#3	Conservation Till	Irrigated	Wheat, fallow, wheat, wheat, fallow	50	10%
#4	Standard Till	Not Irrigated	Corn, soy, fallow, wheat, soy	200	40%

Using this methodology, each project parcel effectively has multiple baseline scenarios. One way to think about this approach would be that for every acre of a project in the above example, 0.2 acres would be converted according to practice #1, 0.3 acres according to practice #2, 0.1 acres according to practice #3, and 0.4 acres according to practice #4.

B.4 Modeling Approach

In order to model baseline emissions for use in quantifying emission reductions, the composite baseline practices defined in Section B.3 were combined with climatic and initial condition inputs. Local weather data inputs were based on values from the North America Regional Reanalysis Product (NARR).[101] Weather for each year in the future was modeled on actual weather from a year in the past (within the last 30 years). Thus, inputs such as temperature and precipitation should reflect recent trends. All modeling was performed using stochastic modeling techniques and the DAYCENT model to evaluate the change in carbon pools and emissions sources across multiple scenarios. More specifically, this was done by modeling the conversion to cropland of IDB locations throughout the U.S. that are currently categorized as grasslands. It includes analysis of the composite baselines defined in Section B.3 in a manner consistent with the compilation of the U.S. Inventory.

Modeling was conducted based on the strata delineated in Section 5.1 of the protocol, which include previous land use in addition to the variables used to define the super strata. For each stratum (unique combination of MLRA, soil texture, and previous land use), the following methodology was employed by utilizing the Colorado State University parallel computing capability, which includes dedicated database servers and a ca. 300 CPU computing cluster:

1. Grassland modeling points were pulled from the IDB or modified for modeling:

[101] NOAA/OAR/ESRL PSD, *North America Regional Reanalysis Product*, available at: http://www.esrl.noaa.gov/psd/.

   a. For long term grassland (30+ years), all 154,639 IDB locations that have been continuous grassland were selected.
   b. For short term grassland (10-30 years) a period of 12-28 years of grassland management preceding project implementation was randomly assigned and area-weighted to 162,460 IDB locations in continuous cropland.
2. Initial carbon pools at project start were established for each data point based on soil data and a long-term spin-up of the DAYCENT model using practices defined in the preceding step.
3. For the 30+ year grassland baseline scenario, each IDB location was modeled forward applying the baseline practices determined in Section B.3 through the DAYCENT model for 50 years. The baseline practices for each IDB location were pulled at random without replacement.
4. For the 10-30 year grassland baseline scenario, each IDB location was modeled forward applying the cropping practices associated with that point in the IDB through the DAYCENT model for 50 years.
5. For the project scenario, each IDB location was modeled forward applying a continuation of the management practices established for the U.S. national GHG inventory analysis.
6. DAYCENT output was summarized as average annual change or emission rates in ten year increments for the following:
   a. Soil organic carbon[102]
   b. N_2O emissions (direct and indirect)
7. The extracted emissions in ten year increments were area-weighted based on IDB area-weights and averaged across points within the strata and translated into average annual per acre emission rates applicable to corresponding ten year increments.

The resulting emission rates are provided by stratum in a tabular form and included as lookup tables[103] where they function as per acre emission factors. A sample of the table format is provided as Table B.3 below.

Table B.3. Sample Output of Emission Factor Table Format

Stratum	Annual Emission Factor (tCO_2e/acre)				
	Year 1-10	Year 11-20	Year 21-30	Year 31-40	Year 41-50

In addition to modeling baseline emissions, the DAYCENT modeling exercise was also performed to estimate project soil carbon emissions or sequestration, emissions from nitrous oxide, and dry matter estimates. The dry matter estimates are used in the quantification portion of this protocol to estimate CH_4 and N_2O emissions from burning on project lands.

Finally, fuel consumption was estimated by applying fuel consumption factors from the NRCS Energy Calculator to the practices modeled at each IDB location. The results from each IDB

[102] Other related pools including above- and below-ground biomass flow through this pool in the modeled carbon balance. Accordingly, this pool is intended to represent net system emissions or sequestration over longer time horizons such as the 50 years modeled in this exercise.
[103] See the Reserve's Grassland Project Protocol webpage at: http://www.climateactionreserve.org/how/protocols/grassland/.

location in the baseline scenario were area-weighted based on IDB area-weights to estimate fuel consumption per acre for each stratum.

B.5 Results

Over 317,099 individual grassland points were modeled to calculate composite emission rates based on 31.7 million point years. However, emission rates have been provided for only a subset of strata within the continental U.S. where data was available and deemed reliable. In order to maintain data integrity and robustness of modeling results, certain strata for which there was limited data were evaluated, but output results were not included in the published tables of emission rates. Specifically, strata with less than ten assigned IDB locations in grassland were excluded due to low sample size. Because strata include soil type (texture), the paucity of points in many cases (especially for coarse and fine soils) reflects the actual low occurrence of a particular soil type within a particular MLRA. Strata with 11-100 data points were considered to be of good availability, while those with more than 101 points were considered excellent data availability. The number of strata assigned to each category of data availability is summarized in Table B.4.

Table B.4. Stratum Availability

Count of strata deemed low availability (≤10 points), good availability (11-100 points), and excellent availability (>100 points)

	Fine		Coarse		Medium		Total Strata
	10-30 years	30+ years	10-30 years	30+ years	10-30 years	30+ years	
≤10 Points	89	70	70	54	45	26	**354**
11-100 Points	64	79	98	77	73	61	**452**
>100 Points	73	77	58	95	108	139	**550**
TOTAL	**226**	**226**	**226**	**226**	**226**	**226**	**1,356**

The maps in Figures B.1 through B.6 illustrate the distribution of the strata for which there was insufficient data to generate reliable emission rates (10 or fewer data points), and those for which there was good or excellent data availability.

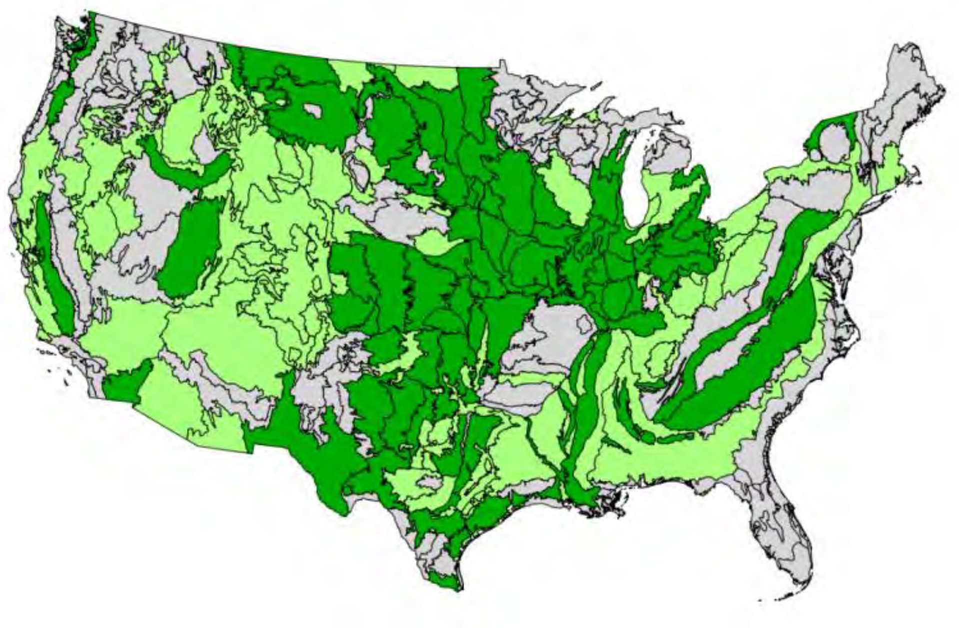

Figure B.1. Map of 10-30 Year Grassland Data Points on Fine Soils

Grey represents 10 or fewer points. Light green represents 11-100, and dark green represents greater than 100 data points. Emission rates have been provided for all green MLRAs.

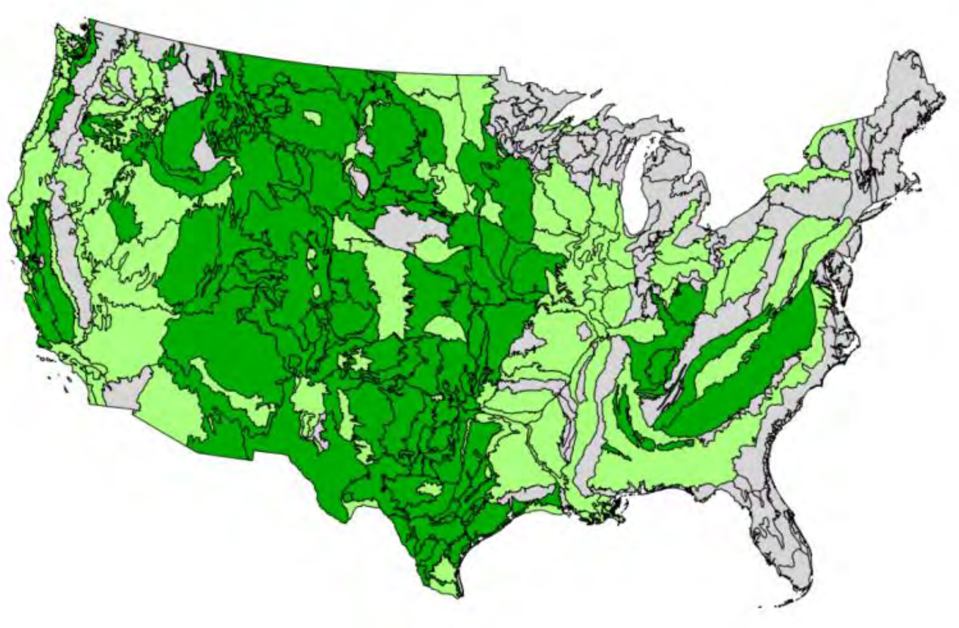

Figure B.2. Map of 30+ Year Grassland Data Points on Fine Soils

Grey represents 10 or fewer points. Light green represents 11-100, and dark green represents greater than 100 data points. Emission rates have been provided for all green MLRAs.

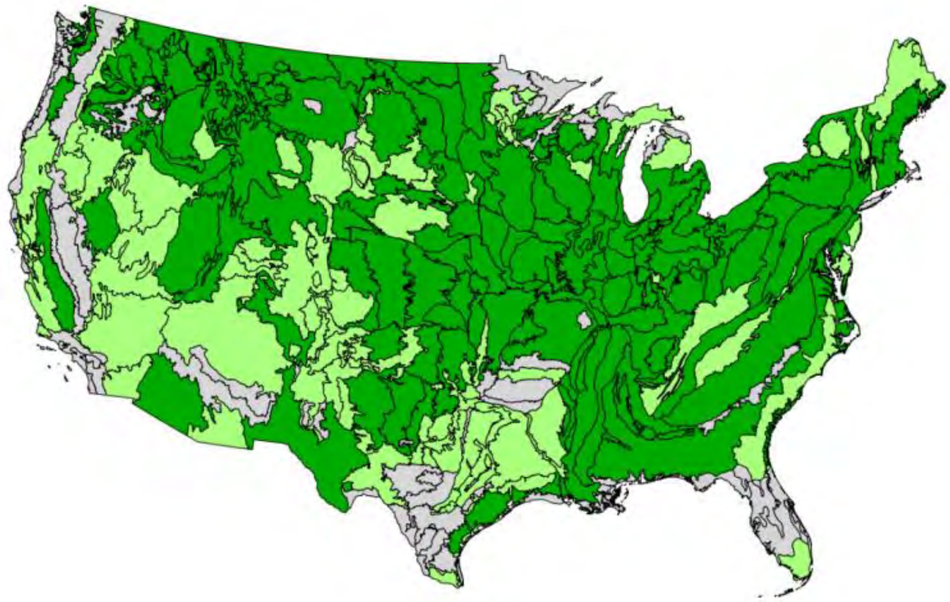

Figure B.3. Map of 10-30 Year Grassland Data Points on Medium Soils

Grey represents 10 or fewer points. Light green represents 11-100, and dark green represents greater than 100 data points. Emission rates have been provided for all green MLRAs.

Figure B.4. Map of 30+ Year Grassland Data Points on Medium Soils

Grey represents 10 or fewer points. Light green represents 11-100, and dark green represents greater than 100 data points. Emission rates have been provided for all green MLRAs.

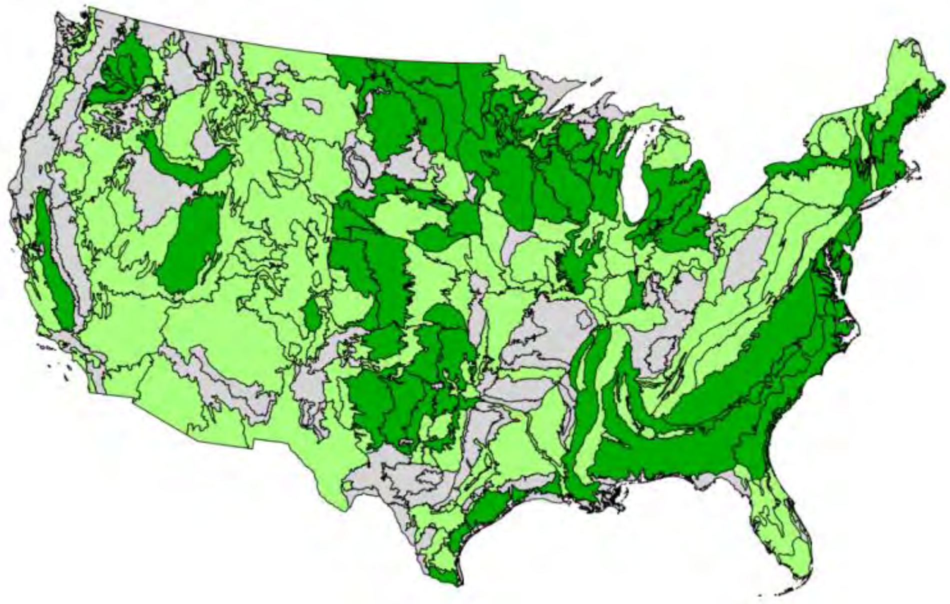

Figure B.5. Map of 10-30 Year Grassland Data Points on Coarse Soils

Grey represents 10 or fewer points. Light green represents 11-100, and dark green represents greater than 100 data points. Emission rates have been provided for all green MLRAs.

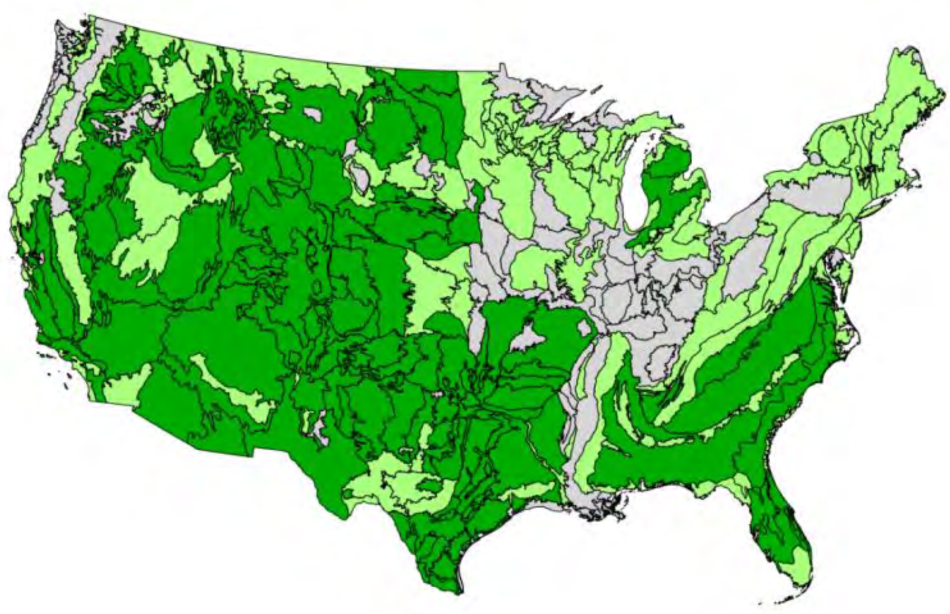

Figure B.6. Map of 30+ Year Grassland Data Points on Coarse Soils

Grey represents 10 or fewer points. Light green represents 11-100, and dark green represents greater than 100 data points. Emission rates have been provided for all green MLRAs.

Due to the size and complexity of the emission rate output tables, results are not provided in the protocol, but instead are available for download in Microsoft Excel format from the Reserve's website.[104] In addition to the emission rate tables, there is an additional file that contains summary statistics for each stratum for which modeling was performed, which is available upon request. Although many variables went into the inputs for each modeling run, this file displays the percent of land that was modeled as irrigated in each stratum, as well as the distribution of crops that contributed to the composite baseline.

B.6 Uncertainty

Although some level of uncertainty is inherent in any modeling exercise, there are several important uncertainties unique to the establishment of baseline conditions and modeling performed over a 50 year horizon. Several sources of uncertainty are particularly noteworthy:

- **Tillage Practice.** The use of no-till and conservation tillage practices in the U.S. has been increasing in recent decades, and this trend is expected to continue. The USDA ERS evaluated tillage data for a variety of crops and geographies across the U.S. and found that no-till has increased at a rate of 1.5% per year between 2000 and 2007, though there is considerable variation across crops and regions. No-till agriculture, particularly when practiced over a prolonged time, has the potential to lower soil carbon emissions or increase sequestration (31).
- **Fertilizer Use.** Inorganic and organic nitrogen are common inputs for many cropping systems in the U.S., and have considerable GHG impacts through both direct and indirect N_2O emissions. Nitrogen management best practices focus on minimizing excess nitrogen in the system by matching the rate, timing, placement, and source of nitrogen to the requirements of the crop system to efficiently utilize nitrogen and maximize crop yields. Despite data showing that nitrogen application rates on some crops have increased even since 1990 (e.g., corn, wheat) (32), emissions from this source may be flat or declining due to increased nitrogen use efficiency and yields. Shifts in practice and technology have the potential to reduce net N_2O emissions from fertilization per unit of yield.
- **Climate Change.** Over the coming decades, weather patterns across the country are expected to change in several ways. Temperatures are projected to rise; the intensity of the heaviest precipitation events is projected to increase; crop yields may be more strongly influenced by anomalous weather events; weeds, diseases and pests may increase crop stress; and other climate disruptions to agricultural production are projected to increase over the next 50 years (33). These impacts will vary considerably across regions, and will have varied impacts on agricultural GHG emissions.

During the workgroup consultation process, the concept of including shifts in tillage practice and fertilizer use within the modeling environment was evaluated. However, because of data and modeling limitations, uncertainty around inputs, and the assumptions required to conduct modeling that included these shifts, it was deemed more appropriate to account for the uncertainty outside of the modeling exercise rather than compromise the model's inherent strengths and data sources. Both tillage and nitrogen management practice will further interact with climate change and weather events, with the result being unknown net impacts to field-level GHG emissions. The quantification methodology includes a discount factor intended to conservatively address the uncertainty associated with these and other factors. The specific uncertainty related to these emission factors has not been quantified. In discussion with the contractor, the Reserve has set the discount as 1% per 10-year emission factor period. Thus,

[104] See the Reserve's Grassland Project Protocol webpage at http://www.climateactionreserve.org/how/protocols/grassland/.

the discount increases as the time of quantification moves farther from the time the modeling was completed. If the Reserve is able to update this modeling exercise at a later date, then the discount for uncertainty will be reset for the new emission factors.

B.7 Justification for a Standardized Baseline

This section provides a brief overview of the benefits associated with use of a highly standardized approach to baseline determination and quantification of baseline emissions.

B.7.1 Transaction Costs and Verifiability

One of the primary goals to standardization is to cut down to the extent practicable on project costs and verification complexity. If the project proponent is required to assert the baseline cropping system and management practice, this would necessitate considerable costs both in project development and verification. Existing protocols rely on resources such as appraisals, government surveys, and universities in establishing baseline cropping systems. While government surveys provide some insight into dominant crops in a region, they are not generally differentiated by relevant soil characteristics, and do not reveal detailed crop rotation information nor do they link across variables (e.g., crop rotations and tillage practices). Further, while appraisals are useful in establishing that land may have a higher value as “cropland” versus grassland, it is unclear that these appraisals would consider specific cropping systems, inputs and management practices. Instead, these appraisals may assess only the publicly available rent information on cropland in the region, itself a composite of multiple practices.

In short, relying on project proponent assertions would require considerable project proponent resources to identify and document the likely cropping system, provided it can reliably be done at all. Additionally, the asserted crop system would need to be verified by the verification body, adding additional costs and uncertainty. Alternatively, the standardized approach does not require the project proponent to assert a baseline cropping system or management practice at all, or the verifier to assure this data. The baseline scenario and emissions estimates are defined exclusively based on geographic, historic, and physical characteristics of the project parcels, most of which are publicly available in national geospatial databases.

B.7.2 Customizability and Opportunity for Gaming

One potential shortcoming of a standardized approach to baseline determination and baseline emissions modeling is that it limits the opportunity for projects to be customized. Greater project proponent input provides greater opportunity to reflect specific knowledge or greater detail. For example, there may be characteristics of the land (e.g., slope) or local market (e.g., proximity to processing) that cannot be captured in the standardized methodology that nonetheless can reasonably be expected to influence cropping or practice.

However, this shortcoming of standardization is also a potential benefit in the ability it provides to avoid gaming. For example, if emission rates for two cropping systems are different, then gaming could occur if project proponents take steps to establish the system with higher emissions as their baseline. Given the complexity of verification and the potential methodological flexibility due to varying levels of data availability that may need to be afforded project proponents in establishing the baseline practice, it is possible that this gaming could occur without detection. Use of standardized composite baselines essentially eliminates this gaming risk by basing stratification and the determination of baseline emissions purely on geographic, historic, and physical characteristics of project parcels, most of which are publicly available in national geospatial databases.

B.7.3 Future Uncertainty

While the uncertainty of knowing what may occur on grassland directly following conversion is obviously significant, the uncertainty about what may occur 10 years or 20 years hence is even greater. Given a crediting period of 50 years, it is therefore extremely important that the baseline determination and associated baseline emissions are not overly influenced by short-term considerations.

Means of evaluating the highest value cropping systems are highly dependent on short-term projections about commodity and crop prices, which are subject to change in the future. As such, even if one knew with certainty that a parcel would be converted to a given crop rotation and management practice tomorrow, there is no reasonable way to know that it would persist in that manner for 10 or 20 years. As such, it is more reasonable to treat each parcel as essentially a composite of a multitude of crop systems in the area reflecting longer term practices and trends.

Appendix C Default Parameters and Emission Factors

Most of the emission factors needed in this protocol can be found in the separate *Grassland Project Parameters* document, which can be downloaded from the protocol website. [105]

C.1 Development of Project Emission Factors for N_2O

To simplify the quantification of N_2O emissions from fertilizer and manure, the Reserve is relying on default values from the IPCC (6). Because of this, the full equation necessary for accounting for emissions from nitrogen volatilization and leaching can be collapsed and simplified by combining multiple constants into a single constant.

Equation 5.10 uses a value of 0.012 to represent direct emissions and emissions from the volatilization of fertilizer. This value is derived thusly:

$$\boldsymbol{A} = \boldsymbol{B} + (\boldsymbol{C} \times \boldsymbol{D})$$

Where,
A = Emission factor for direct and volatilized emissions of N_2O from organic fertilizer (0.012)
B = Emission factor for direction emissions of N_2O from organic fertilizer (0.01)
C = Fraction of organic fertilizer lost to volatilization (0.2)
D = Emission factor for N_2O due to volatilization and deposition (0.01)

Equation 5.10 uses a value of 0.00225 to represent emissions from the leaching of fertilizer. This value is derived thusly:

$$\boldsymbol{Leach} = \boldsymbol{E} \times \boldsymbol{F}$$

Where,
Leach = Default factor for the fraction and emission factor for N_2O emissions due to leaching (0.00225)
E = Fraction of organic fertilizer lost to leaching (0.3)
F = Emission factor for N_2O due to leaching (0.0075)

Equation 5.11 uses a value of 0.22 to represent direct emissions and emissions from the volatilization of manure nitrogen. This value is derived thusly:

$$\boldsymbol{G} = \boldsymbol{H} + (\boldsymbol{I} \times \boldsymbol{J})$$

Where,
G = Emission factor for direct and volatilized emissions of N_2O from manure (0.22)
H = Emission factor for direction emissions of N_2O from manure (0.02)
I = Fraction of organic fertilizer lost to volatilization (0.2)
J = Emission factor for N_2O due to volatilization and deposition (0.01)

Equation 5.11 uses a value of 0.00225 to represent emissions from the leaching of manure nitrogen. This value is the same as the leaching value derived for fertilizer, above.

[105] Default emission factors can be found in a separate document, *Grassland Project Parameters*, available at: http://www.climateactionreserve.org/how/protocols/grassland/.

Appendix D Legal Instruments

Registration of a grassland project under this protocol requires the use of a number of specific legal instruments. This appendix provides additional guidance on the intent and usage of these instruments, as well as any requirements for their use with a grassland project. Table D.1 lists the relevant legal instruments and their relatedprotocol sections.

Table D.1. Legal Instruments Relevant to Grassland Projects

Legal Instrument	When Required	Protocol Section(s)
GHG reduction rights contract	Required when ownership of GHG emission reduction rights are not determined in the conservation easement	2.3.2
Indemnification agreement	Required when there are multiple Grassland Owners who are not party to the legal instruments related to the project	2.3.2
Conservation easement	Required, unless project area is owned by the Federal government	2.2, 3.2, 6.2.1.2
Qualified Conservation Easement	Required, unless project area is owned by the Federal government	3.5.1
Project Implementation Agreement	Required for all projects	3.5.2
Reserve attestations (title, voluntary implementation, regulatory compliance)	Required for all projects	2.3.2, 3.3.2, 3.6
Instruments associated with concurrently-joined conservation programs	Required only if the project area is enrolled in other conservation payment/credit programs	3.3.2.1

D.1 GHG Reduction Rights Contract

Purpose: This contract is required in order to clearly establish ownership over the GHG emission reductions associated with the grassland project. In order to meet the definition of a Project Owner, an entity must be able to demonstrate ownership of the GHG emission reductions associated with the project. Unless existing contracts specify otherwise, it is assumed that the Grassland Owner holds the rights to any GHG emission reductions that would be issued under this protocol. However, the recording of a conservation easement may create the expectation, on the part of the easement holder, that they hold ownership rights that include the GHG emission reductions. In addition, either the Grassland Owner or the easement holder may wish to transfer these rights to a third-party Project Owner. The grantee of the GHG Reduction Rights contract will be the Project Owner of record (the Account Holder) with the Reserve, and will be the entity to which the CRTs are issued upon successful registration of a reporting period. The Project Owner is also the entity who will execute the Project Implementation Agreement.

Parties involved: Grassland Owner, Project Owner, easement holder.

Timing: Ownership of the GHG emission reductions associated with the project activities must be documented during project verification.

Notes:

- May be a standalone document, or it may be incorporated into another legal document, such as the project's conservation easement. A standard, short form version is included as Exhibit B to the PIA.
- Must clarify the ownership of the GHG emission reductions at the time of their creation, rather than just the sale of those credits
- Must clearly define ownership of rights for GHG reductions related to the project activities
- Must be signed by the Grassland Owner, the easement holder, and the Project Owner.
- Must include clauses that specify steps to be taken if ownership changes for either the land, the GHG reduction rights, or the conservation easement
- Recommended inclusions:
    - Description of the project area
    - Description of the offset project and the offset project registry
    - Reference to the GPP as the method of quantifying GHG emission reductions
    - Specific reference to sources of GHG emissions which are covered by GHG assessment boundary for the GPP
    - Discussion of responsibilities in the event of a reversal (see Section 5.4)
    - Any potential exclusions (i.e., GHG or other benefits not covered by this contract)

D.2 Indemnification Agreement

Purpose: Where there may be multiple entities who could meet the definition of Grassland Owner, the Reserve must be indemnified against future GHG reduction claims by those entities which are not acting as Grassland Owner for the purposes of the protocol, and are not party to the GHG reduction rights contract.

Parties involved: Grassland Owner, Project Owner, Climate Action Reserve.

Timing: This agreement must be executed following the initial verification, prior to registration by the Reserve.

Notes: Must indemnify the Reserve in connection with any claims brought by other grassland owners or would-be grassland owners against the Reserve.[106]

D.3 Cooperative Contract

Purpose: For projects participating in a cooperative, this is a contract between the Project Owner and the Cooperative Developer. In general, this contract lays out the terms of the Project Owner's participation in the cooperative. However, its relevance for this protocol is its usefulness as a clear signal from the Project Owner of their intent to initiate a GHG offset project. This is particularly useful for determining the project start date, in order to ensure the additionality of the project.

Parties involved: Project Owner, Cooperative Developer.

Timing: If being used to denote the project start date, then the notarization date of this contract will be chosen by the Cooperative Developer as a date which will result in more efficient management of the cooperative. This date can be no earlier than the earliest recorded easement on any project in the cooperative.

[106] A sample indemnification agreement is available at: http://www.climateactionreserve.org/how/protocols/grassland/.

Notes:

- This contract is only required for projects which wish to use it to denote the project start date. In those cases, this contract must be notarized

D.4 Qualified Conservation Easement (QCE)

Purpose: The conservation easement is the principle mechanism by which the project area is protected against land use change during the project period, and in perpetuity. The QCE is a label applied to a conservation easement whose terms either explicitly prevent reversals of CRTs by referencing the Grassland Project Protocol, or implicitly prevent reversals of CRTs by including land use limitations which are sufficient to prevent land use that would disturb soil carbon in the project area.

Parties involved: Grassland Owner, easement holder, Project Owner (optional).

Timing: In most cases, the execution of the QCE will denote the project start date. In all cases the QCE must be executed prior to completion of the initial verification.

Notes:

- It is recommended that the QCE also include clear discussion of both the carbon rights and the GHG emission reduction rights, as defined in Section 9 (see section above regarding the GHG emission reduction rights contract).
- It is required that the QCE include enforceable provisions for the ongoing monitoring of compliance with the terms of the easement.
- It is recommended that access rights be granted to the Project Owner and the Reserve for the purposes of monitoring and enforcing the provisions of the Protocol.
- If the project is at all likely to include livestock grazing, it is recommended that the QCE include prescriptive guidance for grazing management which explicitly limits grazing intensity.
- It is recommended that the QCE make reference to and incorporate the PIA.

D.5 Project Implementation Agreement (PIA)

Purpose: The PIA is a contract between the Reserve and the Project Owner which binds the Project Owner to the terms of the protocol, including the avoidance of and compensation for reversals, and the monitoring of the project during the permanence period. If the Grassland Owner is the Project Owner, they may elect to have the PIA recorded on the deed to the property, thus binding the landholder to the protocol and reducing the risk of uncompensated reversals.

Parties involved: Project Owner, Climate Action Reserve.

Timing: The PIA is executed during the initial verification of the project, prior to registration and CRT issuance. The terms of the PIA are applicable for 100 years following the issuance of CRTs. The PIA is updated at each subsequent registration in order to extend its term to cover the new CRT issuance, as well as to potentially reflect any changes in Project Ownership.

Notes:

- The Recorded PIA includes a clause specifying whether the PIA may be subordinated to any subsequent deed restrictions. The Project Owner will choose whether to use the Type I (not able to be subordinated) or the Type II (able to be subordinated) clause. Use of the Type II clause results in a value of 0.1 for the risk of financial failure in the calculation of the project's contribution to the risk buffer pool. Use of the Type I clause results in a value of 0 for this parameter.
- The Contract PIA, where the project area itself is not bound by the contract, always results in a value of 0.1 for the risk of financial failure in the calculation of the project's contribution to the risk buffer pool.

D.6 Reserve Attestations

Required attestations:

- Attestation of Title
- Attestation of Voluntary Implementation
- Attestation of Regulatory Compliance

Purpose: These attestations are legal documents whereby the Project Owner legally attests to the truth of the statements and facts necessary to support the conclusions of a positive verification report. The Attestation of Title confirms that the Project Owner is the legal owner of the rights to the GHG emission reductions represented by the CRTs which will be issued into their account. The Attestation of Voluntary Implementation confirms that the project passes the legal requirement test. The Attestation of Regulatory Compliance confirms that the project met the eligibility requirements of Section 3.6 during the reporting period(s).

Parties involved: Project Owner.

Timing: These attestations are completed during verification and apply to a specific period of time for which CRTs are to be issued. The Attestation of Title and Attestation of Regulatory Compliance are completed at every verification. The Attestation of Voluntary Implementation is only completed during the initial verification.

D.7 Other Instruments Associated with Concurrently-Joined Conservation Programs

Purpose: If a project area is enrolled in any other credit or payment program, the contracts or legal instruments associated with that program is relevant to the verification of the offset project. These contracts or instruments must be disclosed to the verifier during the verification process. The verifier shall assess each payment or crediting program against the guidance of Section #, conferring with the Reserve for guidance where appropriate.

Parties involved: Grassland Owner, others as relevant.

Timing: At every verification.

U.S. Landfill Project Protocol V4.0

Protocol Summary

CLIMATE ACTION RESERVE

Project Definition

The installation of a system for capturing and destroying methane gas emitted from a landfill. The installation must exceed any regulatory requirement.

The protocol accepts a wide range of technologies, including:

- Methane destruction onsite (enclosed flare, open flare, electricity generation, thermal energy production)
- Methane transported offsite for destruction (direct-use or pipeline injection)
- Methane used as vehicle fuel (onsite or offsite)

Project Eligibility Requirements

Location: Project must be within the U.S. or its territories.

Start Date: Any project submitted no more than six months after becoming operational. Operational start date may be determined by the project developer but may be no more than 45 days after methane is first destroyed by a project destruction device.

Legal Requirement Test: The project exceeds any reductions that would have occurred as a result of compliance with federal, state or local regulations. The project developer must sign the Attestation of Voluntary Implementation for each reporting period.

Regulatory Compliance: The project must be in material compliance with all federal, state and local laws or regulations. Project developer must sign the Attestation of Regulatory Compliance for each reporting period.

Other Eligibility Requirements:

- Clear ownership of the greenhouse gas (GHG) emissions reductions
- Project must not be registered with any other registry for the same vintages of reductions
- Proper accounting and monitoring

Crediting Period: Projects are eligible to receive credits for 10 years from start date or until failure of the Legal Requirement Test. Project may apply for a second 10-year crediting period.

Reporting Schedule: Project accounting and verification must occur at least every 12 months but may be carried out more frequently.

Performance Standard

- For landfills that are currently venting (not combusting) gas, the installation of a combustion device is eligible
- For landfills previously using a destruction device that would not qualify under this protocol (e.g., passive flares), only gas beyond the pre-project collection and destruction system is considered additional
- If the landfill is currently destroying methane using a destruction device that would otherwise qualify under this protocol, but for some other reason is not eligible, a separate new destruction device must be installed
- Only the landfill gas destroyed beyond the maximum capacity of the baseline destruction device is considered additional
- Landfill gas-to-energy (LFGE) projects in arid regions may not contain greater than 2.17 million MT of waste in place (WIP) and LFGE projects in non-arid regions may not contain greater than 0.72 million MT of WIP

Project Exclusions

- Any collection and destruction device installed to meet regulatory requirements
- Landfills classified as bioreactors
- Displacement of fossil fuel use associated with production of electric power for the grid or injection of gas
- GHG reductions in activities not associated with the installation of a landfill gas collection and destruction system

Important Note: This is only a summary of the protocol. Please read the full protocol for a complete description of project requirements.

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Landfill Project Protocol Version 4.0
ERRATA AND CLARIFICATIONS

The Climate Action Reserve (Reserve) published its Landfill Project Protocol Version 4.0 (LFPP V4.0) in June 2011. While the Reserve intends for the LFPP V4.0 to be a complete, transparent document, it recognizes that correction of errors and clarifications will be necessary as the protocol is implemented and issues are identified. This document is an official record of all errata and clarifications applicable to the LFPP V4.0.[1]

Per the Reserve's Program Manual, both errata and clarifications are considered effective on the date they are first posted on the Reserve website. The effective date of each erratum or clarification is clearly designated below. All listed and registered LFPP projects must incorporate and adhere to these errata and clarifications when they undergo verification. The Reserve will incorporate both errata and clarifications into future versions of the LFPP.

All project developers and verification bodies must refer to this document to ensure that the most current guidance is adhered to in project design and verification. Verification bodies shall refer to this document immediately prior to uploading any Verification Statement to assure all issues are properly addressed and incorporated into verification activities.

If you have any questions about the updates or clarifications in this document, please contact Policy at: policy@climateactionreserve.org or (213) 891-1444 x3.

[1] See Section 4.3.4 of the Climate Action Reserve Program Manual for an explanation of the Reserve's policies on protocol errata and clarifications. "Errata" are issued to correct typographical errors. "Clarifications" are issued to ensure consistent interpretation and application of the protocol. For document management and program implementation purposes, both errata and clarifications to the LFPP are contained in this single document.

Errata and Clarifications (arranged by protocol section)

Section 3

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Section 3

1. Legal Requirement Test for Landfills in California (CLARIFICATION – August 16, 2012)

Section: 3.4.2.2 (State and Local Regulations, Ordinances and Permitting Requirements)

Context: Section 3.4.2 of the protocol states that if an eligible project begins operation at a landfill that later becomes subject to a regulation that calls for the installation of a landfill gas control system, GHG reductions may be reported to the Reserve up until the date that installation is legally required to be operational. The second paragraph of Section 3.4.2.2 on page 10 makes reference to the Landfill Methane Control Measure adopted on June 17, 2010 by the California Air Resources Board.[2] However, this section does not provide guidance on how landfill projects are to determine the status of their eligibility in regards to the Legal Requirement Test for additionality.

Based on the thresholds and timelines contained within the regulation, the Reserve has developed the following guidance for determining the additionality of landfill projects in California, provided that the projects meet all other requirements of the protocol.

Clarification: The California Landfill Methane Control Measure requires an active landfill gas control system (GCCS) to be installed and operated at MSW landfills that exceed the following two thresholds:[3]

- Size threshold: The regulation only applies to landfills with greater than 450,000 tons waste-in-place (WIP)
- LFG threshold: If a landfill exceeds the size threshold, the regulation only applies if the calculated heat input capacity exceeds 3.0 MMBtu/hr

Landfill projects at active landfills that had exceeded both thresholds and had begun operation of a GCCS prior to June 17, 2010 are eligible to receive CRTs for landfill gas destruction that occurs until December 17, 2012.[4] If the same is true at a landfill that was closed or inactive as of June 17, 2010, eligibility extends until December 17, 2013.[5]

Landfill projects with a start date after June 17, 2010 must assess their status against the regulatory thresholds on an ongoing basis. Any project with a start date after June 17, 2010, but prior to exceeding both thresholds must report its landfill's WIP to the Climate Action Reserve during each verification, as of the end of the previous calendar year. Once the size threshold has been exceeded, the project must also calculate the landfill's heat input capacity according to the regulation[6] and report this figure during each verification, as of the end of the previous

[2] http://www.arb.ca.gov/cc/landfills/landfills.htm
[3] If a landfill exceeds both thresholds, there is a third, optional threshold for surface emissions specified in the regulation. For the purposes of this policy, it is conservative to assume that this optional testing and reporting would not have been carried out in the baseline scenario and thus is not included in this guidance.
[4] In the baseline scenario for these sites, a design plan would have been required to be submitted by June 17, 2011. Upon approval of that design plan, the system would have been required to be operational within 18 months, or by December 17, 2012.
[5] Closed or inactive landfills are allowed 30 months from the approval of the GCCS design plan before the system must be operational.
[6] A tool for the annual quantification of landfill gas heat input capacity is available at: http://www.arb.ca.gov/cc/landfills/landfills.htm

calendar year (beginning the year the size threshold is exceeded). If the LFG threshold is exceeded, the project will remain eligible for a period of 30 months for active landfills and 42 months for closed or inactive landfills following December 31 of the year in which the LFG threshold was exceeded. For example, a landfill project verifying a reporting period covering January 2011 through December 2011 would report its WIP and heat input capacity as of December 31, 2011. A landfill project verifying a reporting period covering June 2011 through June 2012 would report its WIP and heat input capacity as of December 31, 2011.

Any project with a start date that occurs after exceeding both thresholds is not eligible.

In all cases, a project must still meet all other criteria of the Landfill Project Protocol.

Example Scenario	Climate Action Reserve Eligibility Status
A project began operation in 2009, having already exceeded the size and LFG thresholds in the regulation. The landfill remains open and active.	Project is eligible until December 17, 2012.
A project began operation in 2009, having already exceeded the size and LFG thresholds in the regulation. The landfill remains open and active. However, the GCCS does not currently meet the requirements of the regulation and must be modified or upgraded.	Project is eligible until December 17, 2012.
A project began operation in 2009. As of December 31, 2011 the landfill has 400,000 tons of WIP. The landfill continues to receive waste.	Project must monitor and report WIP on a calendar year basis. Once the size threshold is exceeded, project must calculate and report heat input capacity on a calendar year basis. Once the LFG threshold is exceeded, the project is eligible for 30 months if the landfill is active and 42 months if the landfill is closed or inactive.
A project began operation in 2011. As of December 31, 2012, the landfill has exceeded the size and LFG thresholds for the first time. The landfill continues to receive waste.	Project is eligible until June 30, 2014.
A project began operation in 2011. The landfill's report to the ARB for the reporting year 2010 indicated that the site had exceeded both the size and LFG thresholds.	Project is not eligible.
A landfill has exceeded both regulatory thresholds and has submitted a design plan to ARB, but has not yet received approval or begun installation.	Project is not eligible.

Section 5

2. Service Providers for Site-Specific Destruction Efficiency Testing (CLARIFICATION – January 21, 2014)

Section: 5.1 (Quantifying Baseline Emissions)

Context: Footnote 22 on page 23 states that service providers used to determine site-specific values for methane destruction efficiency must be "state or local agency accredited." It is not clear what specific options are available and permissible to projects located in a state or locality which does not have an accreditation program for source test service providers. The last paragraph of Section 6.2 on page 33, the comment section of Table 6.1 for Equations 5.4 and 5.12 (DE_i) on page 36, and the first paragraph of page 72 in Appendix C also contain similar language.

Clarification: The intent of this requirement is to ensure that any source testing conducted for the determination of a site specific value for methane destruction efficiency is of a quality that would be acceptable for compliance by a regulatory body. The following text shall be added to the end of footnote 22 on page 23, after the last paragraph of Section 6.2 on page 33, to the end of the comment section of Table 6.1 for Equations 5.4 and 5.12 (DE_i) on page 36, and after the first paragraph of page 72 in Appendix C:

> "If neither the state nor locality relevant to the project site offer accreditation for source testing service providers, projects may use an accredited service provider from another U.S. state or domestic locality. Alternatively, projects may choose a non-accredited service provider, under the following conditions: 1) the service provider must provide verifiable evidence of prior testing which was accepted for compliance by a domestic regulatory agency, and 2) the prior testing procedures must be substantially similar to the procedures used for determining methane destruction efficiency for the project destruction device(s)."

3. Calculating Baseline Emissions (CLARIFICATION – June 18, 2015)

Section: 5.1 (Quantifying Baseline Emissions)

Context: Equation 5.3 on page 22 provides guidance for how to calculate baseline emissions during the reporting period, including discounts that must be applied to account for oxidation and uncertainties associated with monitoring equipment.

The oxidation factor (OX) accounts for the oxidation of methane by soil bacteria. The protocol requires that an OX discount be applied if the landfill does not incorporate a synthetic liner throughout the entire area of the final cover system. No guidance is provided for how to apply the OX discount factor for cover systems that were in place for less than a full reporting period.

The discount factor for uncertainties associated with monitoring equipment (DF) is applied to projects where methane concentration values were taken weekly, rather than continuously. No guidance is provided for how to apply the DF discount factor for methane concentration readings that were taken on a weekly basis using a portable gas analyzer for only part of the reporting period.

Clarification: The intent of the protocol is that both the OX discount factor and the DF discount factor shall only be applied to periods of time during the reporting period for which each factor is applicable. The OX discount factor shall only be applied for the number of days during the reporting period when the landfill did not incorporate a synthetic liner throughout the entire area of the final cover system. The DF discount factor shall only be applied for the number of days during the reporting period when methane concentration values were taken at a frequency that is less than continuous (every 15 minutes). Thus, Equation 5.3 may be calculated separately for different portions of the reporting period, with the results summed to provide a total BE value for the entire reporting period.

Section 6

4. Metering Multiple Destruction Devices (CLARIFICATION – October 26, 2011)

Section: 6.1 (Monitoring Requirements)

Context: Footnote 26 on page 30 states: "A single meter may be used for multiple, identical destruction devices. In this instance, methane destruction in these units will be eligible only if both units are verified to be operational."

The Reserve has determined that in certain situations it may be acceptable for one flow meter to be used to monitor the flow of gas to multiple destruction devices without fulfilling the requirement that they be identical or that they all be operational. Such an arrangement will require extra steps for verification, depending on the situation and the monitoring data that are available.

Clarification: The following text shall replace footnote 26 on page 30:

"A single flow meter may be used for multiple destruction devices under certain conditions. If all destruction devices are of identical efficiency and verified to be operational, no additional steps are necessary for project registration. Otherwise, the destruction efficiency of the least efficient destruction device shall be used as the destruction efficiency for all destruction devices monitored by this meter.

If there are any periods when not all destruction devices are operational, methane destruction during these periods will be eligible provided that the verifier can confirm all of the following conditions are met:

a. The destruction efficiency of the least efficient destruction device in operation shall be used as the destruction efficiency for all destruction devices monitored by this meter; and

b. All devices are either equipped with valves on the input gas line that close automatically if the device becomes non-operational (requiring no manual intervention), or designed in such a manner that it is physically impossible for gas to pass through while the device is non-operational; and

c. For any period where one or more destruction device within this arrangement is not operational, it must be documented that the remaining operational devices have the capacity to destroy the maximum gas flow recorded during the period. For devices other than flares, it must be shown that the output corresponds to the flow of gas."

5. Monitoring Operational Status (CLARIFICATION – October 8, 2013)

Section: 6.1 (Monitoring Requirements)

Context: The first full paragraph of page 32 in Section 6.1 states that "the operational activity of the landfill gas collection system and the destruction devices shall be monitored and documented at least hourly to ensure actual landfill gas destruction."

Certain types of destruction devices, such as internal combustion engines and most large boiler systems, are designed in such a way that gas may not flow through the device if it is not operational. It has not been clear how the requirements of Section 6.1 apply to these devices. There has been confusion related to the Clarification issued on October 26, 2011 regarding Metering Multiple Destruction Devices.

Clarification: The Clarification regarding Metering Multiple Destruction Devices (October 26, 2011) shall not be construed to relax the requirement for hourly operational data for all destruction devices. Rather, that clarification is allowing a specific metering arrangement during periods when one or more devices are *known* to not be operating. In order to know the operational status of a device, it must be monitored. All destruction devices must have their operational status monitored and recorded at least hourly. In other words, the project dataset will include an indication of operational status corresponding to each hour of landfill gas data. If these data are missing or never recorded for a particular device, that device will be assumed to be not operating and no emission reductions may be claimed for landfill gas destroyed by that device during the period when data are missing.

6. Verifying Off-Site Destruction in Direct Use Projects (CLARIFICATION – January 14, 2015)

Section: 6.1 (Monitoring Requirements)

Context: The protocol requires that "the operational activity of the landfill gas collection system and the destruction devices shall be monitored and documented at least hourly" (Section 6.1, page 32). A clarification issued on October 8, 2013 ("Monitoring Operational Status") reiterates that this requirement applies to all destruction devices.

In scenarios where landfill gas is supplied to a third party end-user via a dedicated pipeline pursuant to a direct use agreement, the project developer may have no management control over the off-site destruction device. It has been unclear whether the operational status of those destruction devices must be monitored, or what alternative assurance may be given to verifiers to confirm that the destruction device is operational and project biogas is being destroyed.

Clarification: The following text shall be inserted after the last paragraph of Section 6.1 on page 32:

> "In scenarios where landfill gas is delivered off-site to a third party end user (not to a commercial natural gas transmission and distribution system or to a facility under management control of the project operator), reasonable efforts must be made to obtain data demonstrating the operational status of the destruction device(s). If it is not possible to obtain such data, the verifier must use their professional judgment to confirm that there has been no significant release of project landfill gas and that the project developer is using the appropriate destruction efficiency value. Evidence that may assist a verifier in making a determination to that effect may include, but is not limited to, one or more of the following:
>
> - a signed attestation from the third party operator of the destruction device that no catastrophic failure of destruction or significant release of landfill gas occurred during the reporting period;
> - the verifier confirming the same via an interview with the third party operator;

- examination of the safety features and/or design of the destruction equipment, such that the destruction device does not allow landfill gas to pass through it when non-operational and/or that the project developer is able to switch off the flow of landfill gas off-site in the event of emergencies;
- records that can corroborate the type and level of operation of the destruction device during the reporting period, such as engine output data, etc.

If the verifier is reasonably assured that no significant release of landfill gas has occurred off-site during the reporting period, the project can use the destruction efficiency appropriate to that off-site destruction device, despite the lack of hourly data from a monitoring device confirming operational status."

7. Meter Field Check Procedures (CLARIFICATION – October 8, 2013)

Section: 6.2 (Instrument QA/QC)

Context: The second paragraph below the bulleted list of page 32 in Section 6.2 states that "if the field check on a piece of equipment reveals accuracy outside of a +/- 5% threshold, calibration by the manufacturer or a certified service provider is required for that piece of equipment."

Certain types of gas flow meters and methane analyzers are susceptible to measurement drift due to buildup of moisture or contaminants on the metering sensor, even if the equipment itself is not out of calibration. If the as-found condition of the meter is outside of the accuracy threshold, but the as-left condition (after cleaning) is within the accuracy threshold, it is not clear whether a full calibration is still required for this piece of equipment. In some cases the manufacturer provides specific guidance to the effect that no further calibration is required if the as-left condition shows the meter to be in calibration.

Clarification: The as-found condition (percent drift) of a field check must always be recorded. If the meter is found to be measuring outside of the +/- 5% threshold for accuracy, the data must be adjusted for the period beginning with the last successful field check or calibration event up until the meter is confirmed to be in calibration (unless the last event occurred during the prior reporting period, in which case adjustment is made back to the beginning of the current reporting period). If, at the time of the failed field check, the meter is cleaned and checked again, with the as-left condition found to be within the accuracy threshold, a full calibration is not required for that piece of equipment. This shall be considered a failed field check, followed by a successful field check. The data adjustment shall be based on the percent drift recorded at the time of the failed field check. However, if the as-left condition remains outside of the +/- 5% accuracy threshold (whether or not additional cleaning and accuracy testing occurs), calibration is required by the manufacturer or a certified service provider for that piece of equipment.

8. Field Check Requirements (CLARIFICATION – October 26, 2011)

Section: 6.2 (Instrument QA/QC)

Context: Section 6.2 sets the minimum field check requirements for flow meters and methane analyzers, but allows project developers to conduct field checks more frequently to minimize the risk of drift-related deductions. The protocol states that the field check at the end of the reporting period must be performed by a third-party technician, but it is not clear if additional field checks carried out at the project developer's discretion must also be performed by third-party technicians. Furthermore, it is not clear what action is required if the discretionary field check reveals accuracy outside of the +/- 5% threshold, or how a verification body should treat field checks not performed by a third party.

Clarification: The field check that is required to occur within the last two months of the reporting period must be carried out by a third-party technician. At other times during the reporting period, field checks are not required to be performed by a third-party technician. However, any field check that is not performed by a third-party technician shall be subject to additional verifier scrutiny, and may be deemed invalid for satisfying the requirements of Section 6.2. The following text shall be added to Section 6.2:

> "Additional field checks carried out during the reporting period at the project developer's discretion may be performed by an individual that is not a third-party technician. In this case, the competency of the individual and the accuracy of the field check procedure must be assessed and approved by the verification body. Furthermore, if the field check reveals accuracy outside of the +/- 5% threshold, calibration is required and the data must be scaled as detailed above."

9. Portable Instruments QA/QC (CLARIFICATION – June 3, 2013)

Section: 6.2 (Instrument QA/QC)

Context: Section 6.2 (page 33) states: "If a portable instrument is used (such as a handheld methane analyzer), the portable instrument shall be maintained and calibrated per the manufacturer's specifications, and calibrated at least annually by the manufacturer, by a laboratory approved by the manufacturer, or at an ISO 17025 accredited laboratory. The portable instrument must also be field calibrated to a known sample gas prior to each use."

It has been unclear what sort of portable instruments must satisfy this requirement. Some portable pieces of equipment are used in the process of the field check, but are not themselves instruments that are able to measure and produce data. The Reserve has determined that all portable instruments used for field checks and calibrations that have the ability to measure the parameter that the meter in question would normally measure must themselves be calibrated annually. Some devices however, namely those pieces of equipment that do not produce a data output that could be used in emission reduction calculations, are not considered to be "portable instruments" per the protocol requirement, and must simply be maintained and calibrated according to the manufacturer's specifications.

In addition, the final sentence of this requirement is only intended to apply to portable methane analyzers, rather than all portable instruments.

Clarification: The following text shall replace the second paragraph (cited above) on page 33:

"If a portable instrument either:

1. acquires project data (e.g. a handheld methane analyzer is used to take weekly methane concentration measurements), or

2. is used to field check the calibration accuracy of equipment that acquires project data and the portable instrument produces a data output that is or could be used in emission reduction calculations (i.e. flow or concentration),

the portable instrument shall be maintained and calibrated per the manufacturer's specifications, and calibrated at least annually by the manufacturer, by a laboratory approved by the manufacturer, or at an ISO 17025 accredited laboratory. Other pieces of equipment used for QA/QC of monitoring instruments shall be maintained according to the manufacturer's specifications, including calibration where specified. Portable methane analyzers must also be field calibrated to a known sample gas prior to each use."

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Version 4.0 | June 29, 2011

Landfill

Project Protocol

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Abbreviations and Acronyms

ACF	Actual cubic feet
CAA	Clean Air Act
CARB	California Air Resources Board
CEQA	California Environmental Quality Act
CH_4	Methane
CNG	Compressed natural gas
CO_2	Carbon dioxide
EG	Emission Guidelines
EPA	U.S. Environmental Protection Agency
GHG	Greenhouse gas
IPCC	Intergovernmental Panel on Climate Change
LFG	Landfill gas
LFGE	Landfill gas-to-energy
LNG	Liquefied natural gas
Mg	Mega gram (1,000,000 grams or one tonne, or “t”)
MMT	Million metric tons
MSW	Municipal solid waste
N_2O	Nitrous oxide
NEPA	National Environmental Policy Act
NESHAP	National Emission Standards for Hazardous Air Pollutants
NG	Natural gas
NMOC	Non-methane organic compounds
NSPS	New Source Performance Standards
NSR	New Source Review
PSD	Prevention of Significant Deterioration
QA/QC	Quality Assurance/Quality Control

RCRA	Resources Conservation and Control Act
Reserve	Climate Action Reserve
SCF	Standard cubic feet (60°F and 1 atm)
VOC	Volatile organic compound
WIP	Waste in place

1 Introduction

The Climate Action Reserve (Reserve) Landfill Project Protocol provides guidance to account for and report greenhouse gas (GHG) emission reductions associated with installing a landfill gas collection and destruction system at a landfill.

As the premier carbon offset registry for the North American carbon market, the Climate Action Reserve works to ensure environmental benefit, integrity and transparency in market-based solutions that reduce greenhouse gas (GHG) emissions. It establishes high quality standards for carbon offset projects, oversees independent third-party verification bodies, issues carbon credits generated from such projects and tracks the transaction of credits over time in a transparent, publicly-accessible system. By facilitating and encouraging the creation of GHG emission reduction projects, the Climate Action Reserve program promotes immediate environmental and health benefits to local communities, allows project developers access to additional revenues and brings credibility and value to the carbon market. The Climate Action Reserve is a private 501c(3) nonprofit organization based in Los Angeles, California.

Project developers that install landfill gas capture and destruction technologies use this document to register GHG reductions with the Reserve. This protocol provides eligibility rules, methods to calculate reductions, performance-monitoring instructions, and procedures for reporting project information to the Reserve. Additionally, all project reports receive annual, independent verification by ISO-accredited and Reserve-approved verification bodies. Guidance for verification bodies to verify reductions is provided in the Verification Program Manual and the corresponding Landfill Project Verification Protocol.

This protocol is designed to ensure the complete, consistent, transparent, accurate, and conservative quantification of GHG emission reductions associated with a landfill project.[1]

Project developers must comply with all local, state, and federal municipal solid waste (MSW), air and water quality regulations in order to register GHG reductions with the Reserve. To register GHG reductions with the Reserve, project developers are not required to take an annual entity-level GHG inventory of their MSW operations.

[1] See the WRI/WBCSD GHG Protocol for Project Accounting (Part I, Chapter 4) for a description of GHG accounting principles.

2 The GHG Reduction Project

2.1 Background

Most MSW in the United States is deposited in landfills, where bacteria decompose the organic material. A product of both the bacterial decomposition and oxidation of solid waste is landfill gas, which is composed of methane (CH_4) and carbon dioxide (CO_2) in approximately equal concentrations, as well as smaller amounts of non-methane organic compounds (NMOC), nitrogen (N_2), oxygen (O_2) and other trace gases. If not collected and destroyed, over time, this landfill gas is released to the atmosphere. In the United States, the Environmental Protection Agency (EPA) has concluded that landfills are the largest source of anthropogenic emissions of CH_4, accounting for 25 percent of total CH_4 emissions.[2] However, the solid waste industry has made significant efforts to reduce their GHG emissions over the past 20 years.[3]

There is considerable uncertainty regarding the actual amount of fugitive methane emissions from landfills. Therefore, this protocol does not address fugitive landfill methane emissions. Instead, it addresses the methane that is captured and destroyed in excess of any regulatory requirements.

2.2 Project Definition

For the purpose of this protocol, the GHG reduction project is the use of an eligible qualifying device for destroying methane gas collected at an eligible landfill. Qualifying destruction devices consist of utility flares, enclosed flares, engines, boilers, pipelines, vehicles, or fuel cells. An eligible landfill is one that:

1. Is not subject to regulations or other legal requirements requiring the destruction of methane gas; and
2. Is not a bioreactor, as defined by the US EPA: “a MSW landfill or portion of a MSW landfill where any liquid other than leachate (leachate includes landfill gas condensate) is added in a controlled fashion into the waste mass (often in combination with recirculating leachate) to reach a minimum average moisture content of at least 40 percent by weight to accelerate or enhance the anaerobic (without oxygen) biodegradation of the waste”[4]; and
3. Does not add any liquid other than leachate into the waste mass in a controlled manner.

Captured landfill gas may be destroyed on-site, transported for off-site use or used to power vehicles. Regardless of how project developers use the captured landfill gas, for the project to be eligible to register with the Reserve under this protocol, the ultimate fate of the methane must be destruction.[5]

Landfill gas collection and destruction systems typically consist of wells, pipes, blowers, caps and other technologies that enable or enhance the collection of landfill gas and convey it to a destruction technology. At some landfills, a flare will be the only device where landfill gas is

[2] U.S. Environmental Protection Agency, Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2005, EPA-430-R-07-002 (April 2007).
[3] The updated Draft California Greenhouse Gas Inventory, developed by the Air Resources Board (August 2007), shows significant improvement in fugitive methane emission control at landfills within the state of California.
[4] 40 CFR 63.1990 and 40 CFR 258.28a.
[5] It is possible that at some point landfill gas may be used in the manufacture of chemical products. However, given that these types of projects are few, if any, these projects are not addressed in this protocol.

destroyed. For projects that utilize energy or process heat technologies to destroy landfill gas, such as turbines, reciprocating engines, fuel cells, boilers, heaters, or kilns, these devices will be where landfill gas is destroyed. Most projects that produce energy or process heat also include a flare to destroy gas during periods when the gas utilization project is down for repair or maintenance. Direct use arrangements which entail the piping of landfill gas to be destroyed by an industrial end user at an off-site location are also an eligible approach to destruction of the landfill gas. For instances of direct use, agreements between the project developer and the end user of the landfill gas (i.e. an industrial client purchasing the landfill gas from the project developer), must include a legally binding agreement to assure that the GHG reductions will not be claimed by more than one party.

Projects that utilize landfill methane for energy generation may avoid GHG emissions associated with fossil fuel combustion. However, under this protocol such projects do not receive credit for fossil fuel displacement. Although the Reserve does not issue CRTs for fossil fuel displacement, it strongly supports using landfill methane for energy production.

2.3 The Project Developer

The "project developer" is an entity that has an active account on the Reserve, submits a project for listing and registration with the Reserve, and is ultimately responsible for all project reporting and verification. Project developers may be landfill owners, landfill operators, GHG project financiers, utilities, or independent energy companies. The project developer must have clear ownership of the project's GHG reductions. Ownership of the GHG reductions must be established by clear and explicit title, and the project developer must attest to such ownership by signing the Reserve's Attestation of Title form.[6]

[6] Attestation of Title form available at http://www.climateactionreserve.org/how/projects/register/project-submittal-forms/**.**

3 Eligibility Rules

Projects that meet the definition of a GHG reduction project in Section 2.2 must fully satisfy the following eligibility rules in order to register with the Reserve.

Eligibility Rule I:	Location	→	*U.S. and its territories*
Eligibility Rule II:	Project Start Date	→	*No more than 6 months prior to project submission*
Eligibility Rule III:	Additionality	→	*Meet performance standard*
		→	*Exceed legal requirements*
Eligibility Rule IV:	Regulatory Compliance	→	*Compliance with all applicable laws*

3.1 Location

Under this protocol, only projects located at landfills in the United States and its territories are eligible to register with the Reserve.[7]

3.2 Project Start Date

The project start date shall be defined by the project developer, but must be no more than 45 days after landfill gas is first destroyed in a project destruction device, regardless of whether sufficient monitoring data are available to report reductions. The start date is defined in relation to the commencement of methane destruction, not other activities that may be associated with project initiation or development.

To be eligible, the project must be submitted to the Reserve no more than six months after the project start date. Projects may always be submitted for listing by the Reserve prior to their start date. For projects that are transferring to the Reserve from other offset registries, start date guidance can be found in the Program Manual.

3.3 Project Crediting Period

The Reserve will issue CRTs for GHG reductions quantified and verified using this protocol for a period of ten years following the project start date. However, the Reserve will cease to issue CRTs for GHG reductions if at any point in the future landfill gas destruction becomes legally required at the landfill. If an eligible project has begun operation at a landfill that later becomes subject to a regulation, ordinance or permitting condition that would call for the installation and operation of a landfill gas control system, the Reserve will issue CRTs for GHG reductions achieved up until the date that the landfill gas control system is legally required to be operational.

The project crediting period begins at the project start date regardless of whether sufficient monitoring data are available to verify GHG reductions.

If a project developer wishes to apply for eligibility under a second crediting period, they must do so within the final six months of the initial crediting period.[8] Thus, the Reserve may issue CRTs

[7] Refer to Appendix A for information on the performance standard analysis supporting application of this protocol in the United States.

for GHG reductions quantified and verified according to the U.S. Landfill Project Protocol for a maximum of two ten-year crediting periods from the project start date. Sections 3.4.1 and 3.4.2 describe the requirements to qualify for a second crediting period. Deadlines and requirements for reporting and verification, as laid out in this protocol and the Verification Program Manual, will continue to apply without interruption.

3.4 Additionality

The Reserve strives to register only projects that yield surplus GHG reductions that are additional to what would have occurred in the absence of a carbon offset market.

Projects must satisfy the following tests to be considered additional:

1. The Performance Standard Test
   a. Practice Threshold
   b. Size Threshold (LFGE projects only)
2. The Legal Requirement Test

3.4.1 The Performance Standard Test

Projects pass the Performance Standard Test by meeting a performance threshold, i.e. a standard of performance applicable to all landfill projects, established on an ex-ante basis by this protocol.[9]

For this protocol, the Reserve uses both a technology-specific threshold (or "practice-based" threshold), which serves as "best practice standard" for managing landfill gas fugitive emissions, as well as a size threshold for projects that are generating energy from landfill gas. A project passes the Performance Standard Test if it satisfies all of the following criteria (A and B).

(A) **Practice Threshold**. The project must involve one of the following activities:

1. Installation of a landfill gas collection system and a new qualifying destruction device at an eligible landfill where landfill gas has never been collected and destroyed prior to the project start date.

2. Installation of a new qualifying destruction device at an eligible landfill where landfill gas is currently collected and vented, but has never been destroyed in any manner prior to the project start date.

3. Installation of a new qualifying destruction device at an eligible landfill where landfill gas was collected and destroyed at any time prior to the project start date using:
   a. A non-qualifying destruction device (e.g. passive flare); or
   b. A destruction device that is not otherwise eligible under the protocol (e.g. a destruction device installed prior to the earliest allowable project start date).

---

[8] If a project has reached the end of its initial crediting period prior to the adoption of this version of the protocol, that project may apply for eligibility under a second crediting period within 90 days from the Effective Date of this protocol (Version 4.0). However, deadlines and requirements for reporting and verification, as laid out in this protocol and the Verification Program Manual, will continue to apply without interruption.

[9] The Reserve defined the performance standard based upon an evaluation of landfill practices in the United States. A summary of the performance standard analysis is provided in Appendix A.

4. Installation of additional wells at an eligible closed landfill where landfill gas was collected and destroyed prior to the project start date using a qualifying flare (or flares) that is not otherwise eligible under the protocol (e.g. a flare installed prior to the earliest allowable project start date). The project is only eligible if a qualifying flare continues to be used to destroy collected methane.[10] Installation of additional flares, or flare upgrades, is permitted under this provision, provided that all destruction devices at the landfill site are flares. Only incremental gas collection and destruction (beyond baseline levels) is eligible for crediting.

The practice threshold is applied as of the project start date, and is evaluated at the project's initial verification. If a project upgrades to a newer version of the protocol for a subsequent verification, it must meet the Practice Threshold of that version of the protocol, applied as of the original project start date. If a project is submitted for a second crediting period, it is subject to the Practice Threshold in the most current version of the protocol at that time, applied as of the original project start date.

Destruction devices that were installed temporarily and utilized only for pilot or testing purposes specifically in anticipation of the GHG project shall not be considered in determining project eligibility or quantification. Devices may only be excluded under this provision if they were installed as a direct precursor to the project activity in order to gather information or determine project viability. Verifiable evidence of this intent must be presented.

Changes in landfill ownership, or in the ownership of destruction devices, are not considered in determining prior landfill gas management practices. If landfill gas was previously collected and destroyed by a party other than the project developer, it still qualifies as "prior" collection and destruction.

Under activities (1), (2), and (3) above, expanding a well-field (either in conjunction with, or subsequent to, installing a new destruction device) constitutes a system expansion rather than a separate project. Expanding a well-field is eligible as a new, separate project only if it meets the conditions described in activity (4). In these cases, expanding a well-field initiates a new crediting period.

(B) **Size Threshold (LFGE Projects Only)**. If the energy produced from destruction of any portion of the landfill gas is utilized on- or off-site (e.g. using an engine, turbine, microturbine, fuel cell or boiler), as of the first day of each reporting period[11], the waste in place (WIP) at the landfill must be less than 2.17 MMT for landfills located in "arid" counties and less than 0.72 MMT for landfills located in "non-arid" counties (see Figure A.1).

The size threshold must be applied each time a project is verified.

The Reserve will periodically re-evaluate the appropriateness of the performance standard criteria by updating the analysis in Appendix A.

[10] Projects only pass the practice threshold (activity 4) if the device is a qualifying flare, not a beneficial use destruction device.
[11] For landfills that are required by a regulatory agency to submit an annual WIP report, the most recent of these reports as of the beginning of the reporting period may be used to determine eligibility against the size threshold.

The Reserve recognizes the importance of waste diversion and recycling programs. Therefore, as part of its periodic assessments of the performance threshold, the Reserve will use a stakeholder process to evaluate whether implementation of this protocol has resulted in negative environmental effects, such as increased emissions of criteria pollutants and/or methane. If it is determined that negative environmental effects have occurred, the Reserve will identify and implement revisions to the protocol to prevent such effects from occurring in the future, or may suspend implementation of the protocol if necessary.

If a project developer wishes to apply for a second crediting period, the project must meet the eligibility requirements of the most current version of this protocol, including any updates to the Performance Standard Test.

3.4.2 The Legal Requirement Test

All projects are subject to a Legal Requirement Test to ensure that the GHG reductions achieved by a project would not otherwise have occurred due to federal, state, or local regulations, or other legally binding mandates. Projects pass the Legal Requirement Test when there are no laws, statutes, regulations, court orders, environmental mitigation agreements, permitting conditions, or other legally binding mandates requiring the destruction of landfill gas methane at the project site.[12] To satisfy the Legal Requirement Test, project developers must submit a signed Attestation of Voluntary Implementation form[13] prior to the commencement of verification activities each time the project is verified. In addition, the project's Monitoring Plan (Section 6) must include procedures that the project developer will follow to ascertain and demonstrate that the project at all times passes the Legal Requirement Test.

As of the project start date, landfills collecting and destroying landfill gas to comply with regulations or other legal mandates – or that are required by regulation or legal mandate to install a landfill gas control system in the future – are not eligible to register new projects with the Reserve. Landfills collecting and destroying landfill gas to comply with regulations or other legal mandates are not eligible to register GHG reductions associated with the early installation of gas control systems during landfill expansion into new cells.

If an eligible project begins operation at a landfill that later becomes subject to a regulation, ordinance, or permitting condition that calls for the installation of a landfill gas control system, GHG reductions may be reported to the Reserve up until the date that the installation of a landfill gas control system is legally required to be operational. If the landfill's methane emissions are included under an emissions cap (e.g. under a state or federal cap-and-trade program), emission reductions may likewise be reported to the Reserve until the date that the emissions cap takes effect.

3.4.2.1 Federal Regulations

There are several EPA regulations for MSW landfills that have a bearing on the eligibility of methane collection and destruction projects as voluntary GHG reduction projects. These regulations include:

[12] A project may pass the Legal Requirement Test if a landfill gas control system is installed to treat landfill gas for NMOC in order to comply with a regulation, ordinance, or permitting condition, but destruction of the landfill gas is not the only compliance mechanism available to the landfill operator, and the total mass flow of NMOC for the landfill gas control system is less than the applicable NMOC threshold (see Section 3.4.2.3).

[13] Form available at http://www.climateactionreserve.org/how/projects/register/project-submittal-forms/.

- New Source Performance Standards (NSPS) for MSW Landfills, codified in 40 CFR 60 subpart WWW – Targets landfills that commenced construction or made modifications after May 1991
- Emission Guidelines (EG) for MSW Landfills, codified in 40 CFR 60 subpart Cc. – Targets existing landfills that commenced construction before May 30, 1991, but accepted waste after November 8, 1987
- The National Emission Standards for Hazardous Air Pollutants (NESHAP), codified in 40 CFR 63 subpart AAAA – Regulates new and existing landfills

These regulations require control of non-methane organic compounds (NMOC) from landfills according to certain size and emission thresholds. In most cases, activities to reduce NMOC will also lead to a reduction in CH_4 emissions, as gas collection and destruction is a common NMOC management technique employed at regulated landfills.

Landfills with a design capacity of at least 2.5 million megagrams and 2.5 million cubic meters of municipal solid waste are subject to the NSPS or EG rules. Landfills above the design capacity size cutoff must calculate their annual NMOC emissions using equations or procedures in the NSPS or EG rules. The landfill must install a gas collection and control system within 30 months after the first annual NMOC emissions rate report in which the emissions rate equals or exceeds 50 Mg/yr. A landfill is subject to the NESHAP if the design capacity is at least 2.5 million megagrams and 2.5 million cubic meters of municipal solid waste, and it has estimated uncontrolled emissions equal to or greater than 50 Mg/yr NMOC as calculated according to Section 60.754(a) of the NSPS or U.S. EPA-approved federal, state or tribal plan.

Landfills smaller than 2.5 million megagrams or 2.5 million cubic meters of waste, and those landfills not defined as MSW landfills such as landfills that contain only construction and demolition material or industrial waste, are not usually subject to NSPS, EG or NESHAP.

3.4.2.2 State and Local Regulations, Ordinances and Permitting Requirements

All states are required by the Clean Air Act (CAA) and Subtitle D of the Resource Conservation and Control Act (RCRA Subtitle D) to promulgate rules for landfills. Some landfills that exceed applicable emission thresholds will require site-specific permits requiring controls under the New Source Review (NSR) or Prevention of Significant Deterioration (PSD) permitting program authorized by the CAA and implemented by states. These state-level rules generally follow federal guidelines. However, the state rules can be more stringent, or require the installation of a gas collection and destruction system, or the destruction of volatile organic compounds (VOC), NMOC, or CH_4 earlier, or at smaller facilities, than the federal regulations would require.

For example, on June 17, 2010, California Air Resources Board (CARB) approved a discrete early action measure to reduce methane emissions from landfills. The control measure applies to landfills with greater than 450,000 MT WIP. The regulation reduces methane emissions from landfills by requiring gas collection and control systems where these systems were not previously required, and establishes statewide performance standards to maximize methane capture efficiencies.[14]

In recent years the inclusion of air quality, water quality and even GHG emission control measures in permitting requirements (CEQA, NEPA, etc.) has become more prevalent.

[14] California Air Resources Board, Landfill Methane Control Measure webpage: http://www.arb.ca.gov/cc/landfills/landfills.htm.

State and local governments may regulate MSW landfills by putting in place nuisance laws or requiring solid waste facilities smaller than the facilities regulated by the CAA or RCRA Subtitle D to control landfill gas. Other regulations or ordinances may require minimal gas collection to prevent lateral migration of the landfill gas to neighboring properties. Collection and destruction activities required under NSPS, EG, NESHAP, CAA and other state and local regulations, ordinances or permitting requirements are not eligible as GHG reduction projects.[15]

The Reserve acknowledges that non-CAA programs such as RCRA Subtitle D, water quality regulations and other state and local regulations, ordinances or permitting requirements do not always dictate the installation of a landfill gas collection system as the only compliance mechanism to manage NMOC emissions or VOC water contamination, but that the installation of a landfill gas collection system is commonly the most effective and least demanding compliance mechanism available. Therefore, the installation of a landfill gas collection and destruction system for compliance with non-CAA regulations will not qualify as a GHG reduction project under this protocol unless these projects also meet the eligibility requirements discussed below.

Some water quality, explosive gas mitigation, and local nuisance regulations and ordinances allow for passive landfill gas control systems, which collect and vent landfill gas to the atmosphere, but are not required to treat or destroy the vented gases. Project activities that add a destruction device to a landfill that is only required to implement a passive landfill gas control system pass the Legal Requirement Test.

3.4.2.3 NMOC Threshold

Certain water quality, explosive gas mitigation, and local nuisance regulations or ordinances require landfill gas collection systems. Once the landfill gas is collected and vented, the landfill may then become subject to air quality regulations requiring the control of NMOC emissions. In some instances, the air quality regulations may allow for flexibility in the treatment of landfill gas for NMOC using either destruction devices or other systems such as carbon adsorption (for the latter, the methane would be vented to atmosphere). Even in the regulatory situation where carbon adsorption is a compliance option, oftentimes a landfill gas destruction device will be the preferred compliance mechanism. Where it is determined that the destruction system is the preferred option, the landfill gas control system in question will not pass the Legal Requirement Test.

The Reserve has developed an NMOC emissions threshold to determine the eligibility of projects at landfills where treatment of landfill gas for NMOC is required in order to comply with a regulation, ordinance, or permitting condition, but destruction of the landfill gas is not the only compliance mechanism available to the landfill operator.[16] The applicable threshold depends on whether or not closed flares are required by law at the landfill (e.g. by air district or local regulations). Specifically:

1. For sites at which closed flares are not required by law, a project is eligible if the total mass flow of NMOC for the landfill gas control system is less than 1,775 pounds NMOC per month.

[15] The Reserve acknowledges that the third party verifier will need to exercise some discretion when reviewing permits that require the installation of a landfill gas control system or any portion thereof. Permits tend to include strong language, such as “must” or “shall” install a landfill gas control system, even in the case that a landfill chooses to voluntarily install a landfill gas control system but is required to obtain a permit to do so.

[16] A summary of the development of the NMOC emissions threshold is provided in Appendix B.

2. For sites at which closed flares are required by law, a project is eligible if the total mass flow of NMOC for the landfill gas control system is less than 2,575 pounds NMOC per month.

By default, projects must use the lower of the two thresholds. In order to use the higher threshold, the project developer must demonstrate to the satisfaction of a Reserve-approved verification body that an open flare could not be permitted at the landfill in question.

If the total mass flow of NMOC for the landfill gas control system is greater than the applicable NMOC threshold, then the landfill gas control system is not eligible as a GHG reduction project under this protocol.

3.5 Regulatory Compliance

As a final eligibility requirement, project developers must attest that the project is in material compliance with all applicable laws (e.g. air, water quality, safety, etc.) prior to verification activities commencing each time a project is verified. Project developers are required to disclose in writing to the verifier any and all instances of non-compliance of the project with any law. If a verifier finds that a project is in a state of recurrent non-compliance or non-compliance that is the result of negligence or intent, then CRTs will not be issued for GHG reductions that occurred during the period of non-compliance. Non-compliance solely due to administrative or reporting issues, or due to “acts of nature,” will not affect CRT crediting.

4 The GHG Assessment Boundary

The GHG Assessment Boundary delineates the GHG sources, sinks, and reservoirs (SSRs) that shall be assessed by project developers in order to determine the total net change in GHG emissions caused by a landfill project.

This protocol does not account for carbon dioxide emission reductions associated with displacing grid-delivered electricity or fossil fuel use.

CO_2 emissions associated with the generation and destruction of landfill gas are considered biogenic emissions[17] (as opposed to anthropogenic) and are not be included in the GHG Assessment Boundary. This is consistent with the Intergovernmental Panel on Climate Change's (IPCC) guidelines for captured landfill gas.[18]

Figure 4.1 below provides a general illustration of the GHG Assessment Boundary, indicating which SSRs are included or excluded from the boundary. All SSRs within the dashed line are accounted for under this protocol.

Table 4.1 provides greater detail on each SSR and provides justification for the inclusion or exclusion of SSRs and gases from the GHG Assessment Boundary.

[17] The rationale is that carbon dioxide emitted during combustion represents the carbon dioxide that would have been emitted during natural decomposition of the solid waste. Emissions from the landfill gas control system do not yield a net increase in atmospheric carbon dioxide because they are theoretically equivalent to the carbon dioxide absorbed during plant growth.

[18] *IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories*; p.5.10, ftnt.

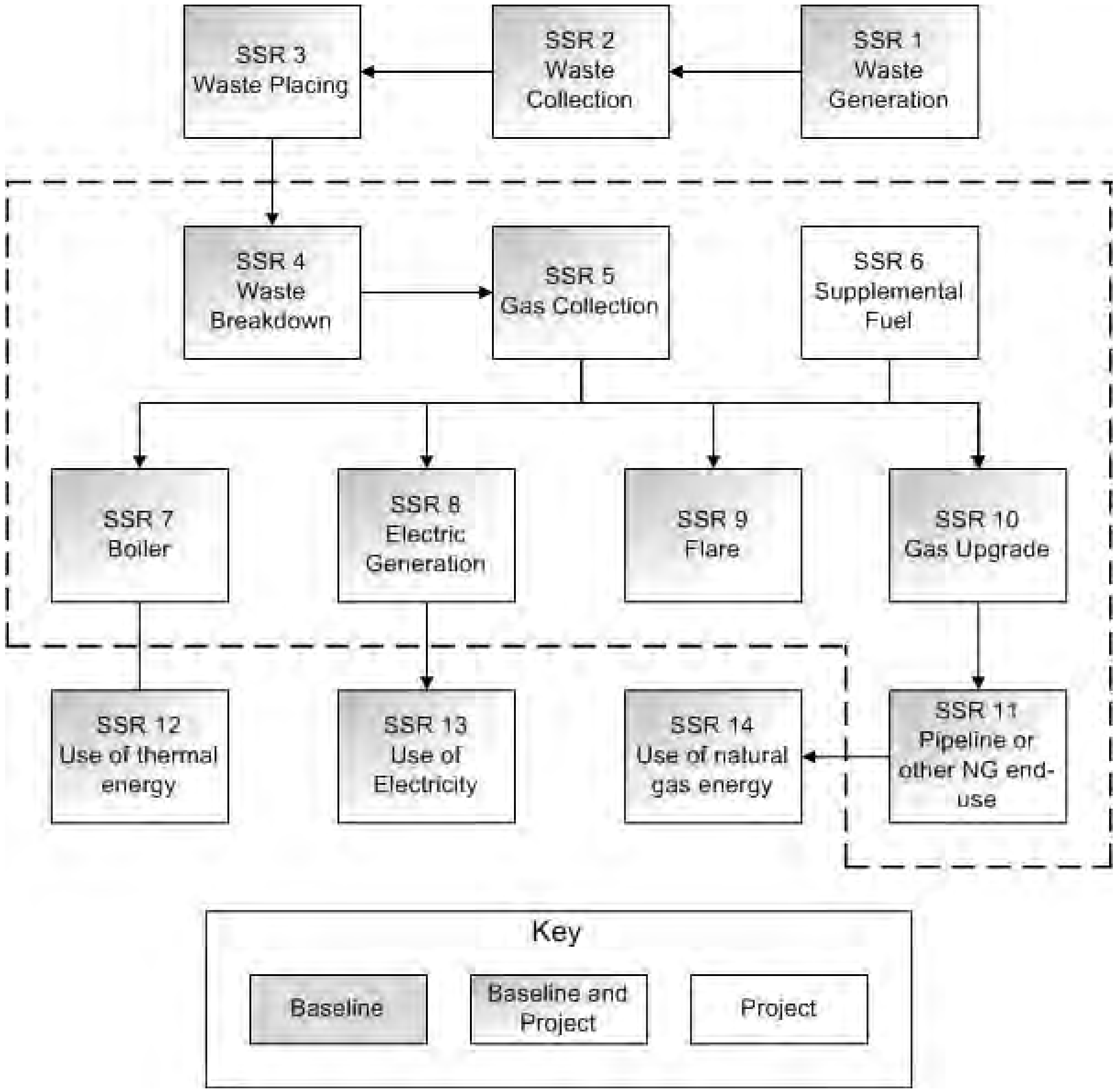


Figure 4.1. General Illustration of the GHG Assessment Boundary

Table 4.1. Summary of Identified Sources, Sinks, and Reservoirs

SSR	Source	Gas	Relevant to Baseline (B) or Project (P)	Included/ Excluded	Justification/Explanation
1	Emissions from Waste Generation	N/A	B,P	Excluded	GHG emissions from this source are assumed to be equal in the baseline and project scenarios
2	Emissions from Waste Collection	CO_2	B,P	Excluded	GHG emissions from this source are assumed to be equal in the baseline and project scenarios
		CH_4		Excluded	GHG emissions from this source are assumed to be equal in the baseline and project scenarios
		N_2O		Excluded	GHG emissions from this source are assumed to be equal in the baseline and project scenarios s
3	Emissions from Waste Placing Activities	CO_2	B,P	Excluded	GHG emissions from this source are assumed to be equal in the baseline and project scenarios
		CH_4		Excluded	GHG emissions from this source are assumed to be equal in the baseline and project scenarios
		N_2O		Excluded	This emission source is assumed to be equal in the baseline and project scenarios
4	Emissions from Waste Breakdown in Landfill	CO_2	B,P	Excluded	Biogenic CO_2 emissions are excluded
		CH_4		Included	Primary source of GHG emissions in baseline. Calculated based on destruction in baseline and project destruction devices.
5	Emissions from Gas Collection System	CO_2	P	Included	Landfill projects result in CO_2 emissions associated with the energy used for collection and processing of landfill gas
		CH_4		Excluded	This emission source is assumed to be very small
		N_2O		Excluded	This emission source is assumed to be very small
	Emissions from Baseline Gas Collection System	CO_2	B	Excluded	This emission source is assumed to be very small
		CH_4		Excluded	This emission source is assumed to be very small
		N_2O		Excluded	This emission source is assumed to be very small
6	Emissions from Supplemental Fuel	CO_2	P	Included	Landfill projects may require use of supplemental fossil fuel, resulting in significant new GHG emissions
		CH_4		Included	Calculated based on destruction efficiency of destruction device
		N_2O		Excluded	This emission source is assumed to be very small
	Emissions from Baseline Supplemental Fuel Use	CO_2	B	Excluded	This emission source is assumed to be very small
		CH_4		Excluded	This emission source is assumed to be very small
		N_2O		Excluded	This emission source is assumed to be very small

SSR	Source	Gas	Relevant to Baseline (B) or Project (P)	Included/ Excluded	Justification/Explanation
7	Emissions from Project LFG Boiler Destruction	CO_2	P	Excluded	Biogenic CO_2 emissions are excluded
		CH_4		Included	Calculated in reference to destruction efficiency
		N_2O		Excluded	This emission source is assumed to be very small
	Emissions from Baseline LFG Boiler Destruction	CO_2	B	Excluded	Biogenic CO_2 emissions are excluded
		CH_4		Included	Calculated in reference to destruction efficiency
		N_2O		Excluded	This emission source is assumed to be very small
8	Emissions from Project LFG Electricity Generation	CO_2	P	Excluded	Biogenic CO_2 emissions are excluded
		CH_4		Included	Calculated in reference to destruction efficiency
		N_2O		Excluded	This emission source is assumed to be very small
	Emissions from Baseline LFG Electricity Generation	CO_2	B	Excluded	Biogenic CO_2 emissions are excluded
		CH_4		Included	Calculated in reference to destruction efficiency
		N_2O		Excluded	This emission source is assumed to be very small
9	Emissions from Project LFG Flare Destruction	CO_2	P	Excluded	Biogenic CO_2 emissions are excluded
		CH_4		Included	Calculated in reference to destruction efficiency
		N_2O		Excluded	This emission source is assumed to be very small
	Emissions from Baseline LFG Flare Destruction	CO_2	B	Excluded	Biogenic CO_2 emissions are excluded
		CH_4		Included	Calculated in reference to destruction efficiency
		N_2O		Excluded	This emission source is assumed to be very small
10	Emissions from Upgrade of LFG	CO_2	B,P	Included	Landfill projects may result in GHG emissions from additional energy used to upgrade landfill gas
		CH_4		Excluded	This emission source is assumed to be very small
		N_2O		Excluded	This emission source is assumed to be very small
11	Emissions from Project LFG Pipeline or other NG end-use	CO_2	P	Excluded	Biogenic emissions are excluded
		CH_4		Included	Calculated in reference to destruction efficiency
		N_2O		Excluded	Assumed to be very small
	Emissions from Baseline LFG Pipeline or other NG end-use	CO_2	B	Excluded	Biogenic emissions are excluded
		CH_4		Included	Calculated in reference to destruction efficiency
		N_2O		Excluded	This emission source is assumed to be very small
12	Use of Project Generated Thermal Energy	CO_2	P	Excluded	This protocol does not cover displacement of GHG emissions from use of LFG-generated thermal energy
	Use of Baseline Generated Thermal Energy	CO_2	B	Excluded	This protocol does not cover displacement of GHG emissions from use of LFG-generated thermal energy

SSR	Source	Gas	Relevant to Baseline (B) or Project (P)	Included/ Excluded	Justification/Explanation
13	Use of Project Generated Electricity	CO_2	P	Excluded	This protocol does not cover displacement of GHG emissions from use of LFG-generated electricity.
	Use of Baseline Generated Electricity	CO_2	B	Excluded	This protocol does not cover displacement of GHG emissions from use of LFG-generated electricity.
14	Use of Natural Gas Energy	CO_2	P	Excluded	This protocol does not cover displacement of GHG emissions from use of LFG delivered through pipeline or other end uses
	Use of Baseline Natural Gas Energy	CO_2	B	Excluded	This protocol does not cover displacement of GHG emissions from use of LFG delivered through pipeline or other end uses

5 Quantifying GHG Emission Reductions

GHG emission reductions from a landfill project are quantified by comparing actual project emissions to baseline emissions at the landfill. Baseline emissions are an estimate of the GHG emissions from sources within the GHG Assessment Boundary (see Section 4) that would have occurred in the absence of the landfill project. Project emissions are actual GHG emissions that occur at sources within the GHG Assessment Boundary. Project emissions must be subtracted from the baseline emissions to quantify the project's total net GHG emission reductions (Equation 5.1).

GHG emission reductions must be quantified and verified on at least an annual basis. Project developers may choose to quantify and verify GHG emission reductions on a more frequent basis if they desire. The length of time over which GHG emission reductions are quantified and verified is called the "reporting period".

The calculations provided in this protocol are derived from internationally accepted methodologies.[19] Project developers shall use the calculation methods provided in this protocol to determine baseline and project GHG emissions in order to quantify GHG emission reductions.

Models that estimate biological and physical processes, such as the biological decomposition of solid waste in landfills and the migration of the landfill gas to the atmosphere are becoming increasingly refined and available. Process models typically rely on a series of input data that research has shown to be important drivers of the biological and geochemical process. In terms of GHG emission models, process models identify the mathematical relationships between inputs, basic conditions, and GHG emissions. The procedure for modeling landfills can be quite complex and subject to many different interpretations of how to address site-specific landfill gas generation factors and how to apply models effectively to landfills. At this time, no widely accepted method exists for determining the total amount of uncontrolled landfill gas emissions to the atmosphere from landfills. As new technologies and/or widely accepted modeling methods become available for the estimation of fugitive methane emissions from landfills, the Reserve will consider updating the protocol to incorporate these new approaches into the methane emission reduction quantification methodologies.

[19] The Reserve's GHG reduction calculation method is derived from the Kyoto Protocol's Clean Development Mechanism (ACM0001 V.6 and AM0053 V.1), the EPA's Climate Leaders Program (Draft Landfill Offset Protocol, October 2006), the GE AES Greenhouse Gas Services Landfill Gas Methodology V.1, and the RGGI Model Rule (January 5, 2007).

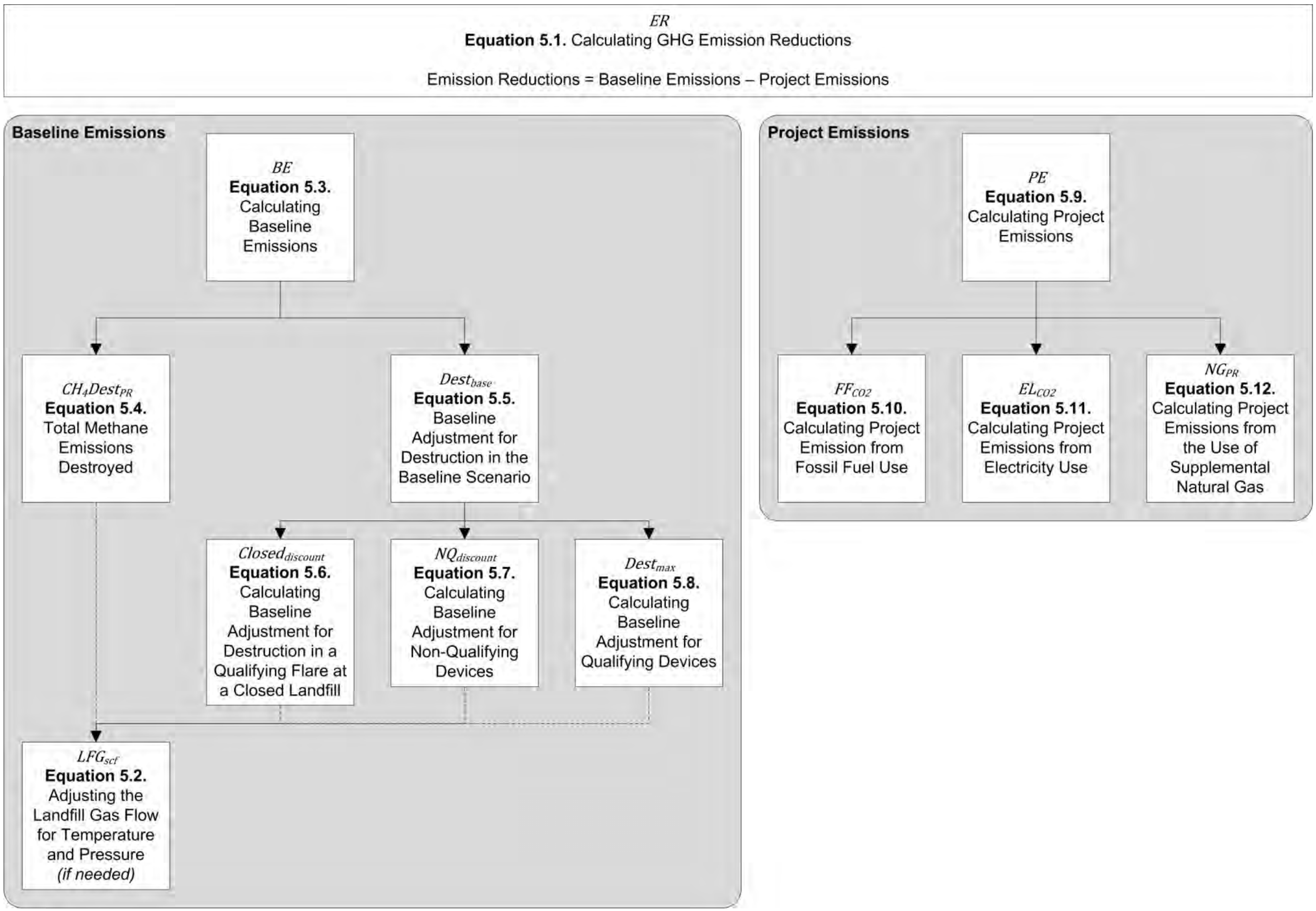


Figure 5.1. Organizational Chart for Equations in Section 5

Equation 5.1. Calculating GHG Emission Reductions

$$ER = BE - PE$$

Where,			<u>Units</u>
ER	=	GHG emission reductions of the project activity during the reporting period	tCO_2e
BE	=	Baseline emissions during the reporting period	tCO_2e
PE	=	Project emissions during the reporting period	tCO_2e

If any of the landfill gas flow metering equipment does not internally correct for the temperature and pressure of the landfill gas, separate pressure and temperature measurements must be used to correct the flow measurement. Corrected values must be used in all of the equations of this section. Apply Equation 5.2 only if the landfill gas flow metering equipment does not internally correct for temperature and pressure.

Equation 5.2. Adjusting the Landfill Gas Flow for Temperature and Pressure

$$LFG_{i,t} = LFG_{unadjusted} \times \frac{520}{T} \times \frac{P}{1}$$

Where,			<u>Units</u>
$LFG_{i,t}$	=	Adjusted volume of landfill gas fed to the destruction device i, in time interval t	scf
$LFG_{unadjusted}$	=	Unadjusted volume of landfill gas collected for the given time interval	acf
T	=	Measured temperature of the landfill gas for the given time period (°R = °F + 459.67)	°R
P	=	Measured pressure of the landfill gas in for the given time interval	atm

5.1 Quantifying Baseline Emissions

Traditional baseline emission calculations are not required for this protocol for the quantification of methane reductions. The baseline scenario assumes that all uncontrolled methane emissions are released to the atmosphere except for the portion of methane that would be oxidized by bacteria in the soil of uncovered landfills absent the project,[20] or destroyed by a baseline destruction device. Therefore, with the exception of the deductions outlined below, baseline emissions are equal to the sum of all methane destroyed by eligible destruction devices.

As noted in Section 3.4.1, projects may fall into four categories based on the baseline state of the landfill and level of landfill gas management. Each of these categories requires a slightly different methodology for calculating relevant baseline emissions.

1. Landfills where no previous collection or destruction took place prior to the project start date must deduct the following from baseline emissions:

[20] Landfill cover systems incorporating a synthetic liner throughout the entire area of the final cover system should use a default methane oxidation rate of zero. A 10% methane oxidation factor shall be used for all other landfills. A small portion of the methane generated in landfills (around 10%) is naturally oxidized to carbon dioxide by methanotrophic bacteria in the cover soils of well managed landfills. The 10% factor is based on Intergovernmental Panel on Climate Change (IPCC) guidelines (2006).

   a. The amount of methane that would have been oxidized by soil bacteria in the absence of the project.

2. Landfills where previous collection and/or destruction took place in a non-qualifying destruction device must deduct the following from baseline emissions:
   a. The amount of methane destroyed by the non-qualifying destruction device.
   b. The amount of methane that would have been oxidized by soil bacteria in the absence of the project.

3. Landfills where previous collection and destruction took place in a qualifying destruction device must deduct the following from baseline emissions:
   a. The amount methane that could have been destroyed if the baseline destruction device was operating at full capacity.
   b. The amount of methane that would have been oxidized by soil bacteria in the absence of the project.

4. Closed landfills where previous collection and destruction took place in a qualifying flare must deduct the following from baseline emissions:
   a. The amount of methane collected by baseline landfill gas wells and destroyed in the qualifying flare.
   b. The amount of methane that would have been oxidized by soil bacteria in the absence of the project.

These conditions ensure that the reductions resulting from the GHG project can be accounted for separately from collection and destruction that would have occurred from the baseline equipment. Only the landfill gas destroyed beyond what would have been destroyed by the baseline collection and destruction system is considered eligible for crediting.

Baseline emissions shall be calculated using Equation 5.3.

Equation 5.3. Calculating Baseline Emissions

$$BE = (CH_4Dest_{PR}) \times 21 \times (1 - OX) \times (1 - DF) - Dest_{base} \times (1 - OX)$$

Where,

			Units
BE	=	Baseline emissions during the reporting period	tCO_2e
CH_4Dest_{PR}	=	Total methane destroyed by the project landfill gas collection and destruction system during the reporting period (see Equation 5.4)	tCH_4
21	=	Global Warming Potential factor of methane to carbon dioxide equivalent[21]	
OX	=	Factor for the oxidation of methane by soil bacteria. Equal to 0.10 for all landfills except those that incorporate a synthetic liner throughout the entire area of the final cover system, where OX = 0	
$Dest_{base}$	=	Adjustment to account for baseline LFG destruction device (see Equation 5.5). Equal to zero if no baseline LFG destruction system is in place prior to project implementation	tCO_2e
DF	=	Discount factor to account for uncertainties associated with the monitoring equipment. (See Section 6.1.) Equal to zero if using continuous methane monitoring	

The term CH_4Dest_{PR} represents the amount of methane destroyed by the project. This term is calculated according to Equation 5.4.

[21] IPCC Second Assessment Report: Climate Change 1996.

Equation 5.4. Total Methane Emissions Destroyed

$$CH_4Dest_{PR} = \sum_i (CH_4Dest_i) \times (0.0423 \times 0.000454)$$

Where,			Units
CH_4Dest_{PR}	=	Total methane destroyed by the project landfill gas collection and destruction system during the reporting period	tCH_4
$CH_4\ Dest_i$	=	The net quantity of methane destroyed by destruction device i (flare, engine, boiler, upgrade, etc.) during the reporting period	scf CH_4
0.0423	=	Density of methane	$lbCH_4$/ scf CH_4
0.000454	=	Conversion factor	tCH_4/ $lbCH_4$

And,

$$CH_4Dest_i = Q_i \times DE_i$$

Where,			Units
$CH_4\ Dest_i$	=	The net quantity of methane destroyed by device i during the reporting period	scf
Q_i	=	Total quantity of landfill methane sent to destruction device i during the reporting period	scf
DE_i	=	Default methane destruction efficiency for device i. [22,23] See Appendix C for default factors	

And,

$$Q_i = \sum_t \left[LFG_{i,t} \times PR_{CH_4,t}\right]$$

Where,			Units
Q_i	=	Total quantity of landfill methane sent to destruction device i during the reporting period	scf
$LFG_{i,t}$	=	Adjusted volume of landfill gas fed to the destruction device i, in time interval t	scf
t	=	Time interval for which LFG flow and concentration measurements are aggregated. See Table 6.1 for guidance.	
$PR_{CH4,t}$	=	The average methane fraction of the landfill gas in time interval t	scf CH_4/ scf LFG

For projects where methane was destroyed in the baseline, Equation 5.5 must be applied. This equation accounts for the methane emissions calculated in Equation 5.4 which would have been destroyed in the absence of the project activity.

[22] If available, the official source tested methane destruction efficiency shall be used in place of the default methane destruction efficiency. Otherwise, project developers have the option to use either the default methane destruction efficiencies provided, or the site specific methane destruction efficiencies as provided by a state or local agency accredited source test service provider, for each of the combustion devices used in the project case.

[23] The default destruction efficiencies for enclosed flares and electricity generation devices are based on a preliminary set of actual source test data provided by the Bay Area Air Quality Management District. The default destruction efficiency values are the lesser of the twenty fifth percentile of the data provided or 0.995. These default destruction efficiencies may be updated as more source test data is made available to the Reserve.

Any project at a landfill where methane was collected and destroyed at any time prior to the project start date – even if the prior collection and/or destruction system was removed or has been dormant for an extended period of time – must apply the baseline deduction. The time period over which the value of $Dest_{base}$ is to be aggregated, using Equation 5.5, may be chosen by the project developer, but cannot be less than weekly, and must be consistent throughout the reporting period.

Equation 5.5. Baseline Adjustment for Destruction in the Baseline Scenario

$$Dest_{base} = \left(Closed_{discount} + NQ_{discount} + Dest_{\max}\right) \times 0.0423 \times 0.000454 \times 21$$

Where,			Units
$Dest_{base}$	=	Adjustment to account for the baseline methane destruction associated with a baseline destruction device. Equal to zero if there is no baseline installation	tCO_2e
$Closed_{discount}$	=	Adjustment to account for the methane that would have been combusted in the baseline flare from baseline wells at a closed landfill. Equal to zero if the project is not a flare project at a closed landfill	scf CH_4
$NQ_{discount}$	=	Adjustment to account for the methane that would have been combusted in the baseline, non-qualifying combustion device. Equal to zero if there is no non-qualifying combustion device	scf CH_4
$Dest_{max}$	=	Deduction of the un-utilized capacity of the baseline destruction device. This deduction is to be applied only when a new destruction device is used during project activity. See Box 5.1 below for an example of the application of the $Dest_{max}$ adjustment	scf CH_4
0.0423	=	Density of methane	$lbCH_4$/ scf CH_4
0.000454	=	Conversion factor	
21	=	Global Warming Potential factor of methane to carbon dioxide equivalent	tCH_4/ $lbCH_4$

Equation 5.6. Calculating Baseline Adjustment for Destruction in a Qualifying Flare at a Closed Landfill

$$Closed_{discount} = LFG_{B1} \times B_{CH_4,closed}$$

Where,

			Units
$Closed_{discount}$	=	Adjustment to account for the methane which would have been combusted in the baseline flare from baseline wells at a closed landfill. Equal to zero if the project is not a flare project at a closed landfill	scf CH_4
LFG_{B1}	=	Landfill gas from the baseline landfill gas wells that would have been destroyed by the qualifying destruction system during the reporting period. See Appendix D for guidance on calculating LFG_{B1}	scf
$B_{CH4,closed}$	=	Methane fraction of landfill gas destroyed by the collection system during the reporting period. See Appendix D for guidance on calculating $B_{CH4,closed}$	scf CH_4/ scf LFG

$NQ_{discount}$, may be determined using either of the following options.

1. $NQ_{discount}$ shall be equal to the measured quantity of methane recovered through an active gas collection system installed into the corresponding cell or waste mass of the landfill in which the baseline devices operated. The landfill gas flow from these active wells shall be determined using Equation 5.4 above for a minimum of one month.[24]

2. $NQ_{discount}$ shall be monitored and calculated per Equation 5.7 and Appendix D.

Equation 5.7. Calculating Baseline Adjustment for Non-Qualifying Devices

$$NQ_{discount} = LFG_{B2} \times B_{CH_4,NQ}$$

Where,

			Units
$NQ_{discount}$	=	Adjustment to account for the methane that would have been combusted in the baseline, non-qualifying combustion device. Equal to zero if there is no non-qualifying combustion device	scf CH_4
LFG_{B2}	=	Landfill gas that would have been destroyed by the original, non-qualifying destruction system during the reporting period. See Appendix D for guidance on calculating LFG_{B2}	scf
$B_{CH4,NQ}$	=	Methane fraction of landfill gas destroyed by non-qualifying devices in the baseline. Equal to average methane concentration over the reporting period if maximum capacity is used for LFG_{B2}. See Appendix D for further guidance on calculating $B_{CH4,NQ}$	scf CH_4/ scf LFG

[24] For the purpose of using Equation 5.4 to determine $NQ_{discount}$, the quantity of landfill gas would be only that which is being metered from the corresponding cell or waste mass in which the baseline devices had operated, and not necessarily all of the landfill gas being destroyed by the destruction system.

Equation 5.8. Calculating Baseline Adjustment for Qualifying Devices

$$Dest_{\max} = \sum_t \left[\left(LFG_{B\max,t} - LFG_{B3,t} \right) \times PR_{CH_4,t} \right]$$

Where, Units

$Dest_{max}$	=	Deduction of the un-utilized capacity of the baseline destruction device. This deduction is to be applied only when a new destruction device is used during project activity. See Box 5.1 below for an example of the application of the $Dest_{max}$ adjustment	scf CH_4
$LFG_{Bmax,t}$	=	The maximum landfill gas flow capacity of the baseline methane destruction device in time interval t	scf/t
$LFG_{B3,t}$	=	The actual landfill gas flow of the baseline methane destruction device in time interval t	scf/t
$PR_{CH4,t}$	=	The average methane fraction of the landfill gas in time interval t as measured	scf CH_4 /scf LFG
t	=	Time interval for which LFG flow and concentration measurements are aggregated. See Table 6.1 for guidance	

Box 5.1. Applying the $Dest_{max}$ Adjustment

This adjustment was designed to help differentiate system upgrades from additional projects, while encouraging project developers to use their landfill gas beneficially. In short, this methodology assumes that any gas which *could* have been destroyed in the baseline qualifying device is not additional; diversion of that gas to a new destruction device represents an upgrade. Therefore, this term deducts from calculated project reductions that portion of gas which, in the absence of the new destruction device, still could have been destroyed.

Example:
A flare with a capacity of 1000 cfm was installed at a landfill in 1998. Therefore, because this flare was operational before 2001, the landfill gas control system is ineligible as a project under this protocol. However, in 2005, an electric generator with a 2000 cfm capacity was installed, and all landfill gas was diverted to this device. The addition of the electric generator meets the eligibility requirements of this protocol, and therefore qualifies as a new project. Because the baseline flare is a qualifying destruction device under this protocol and is not eligible as a project due to other eligibility criteria (i.e. operational date), it must be accounted for using $Dest_{max}$.

In 2005, 900 cfm was sent to generator, and 0 cfm was sent to the flare. In the year 2006, due to landfill expansion and installation of additional wells, the generator destroyed 1400 cfm while the flare was non-operational. In 2007, further well expansion allowed the generator to operate at full capacity and the flare was used to destroy an additional 300 cfm of landfill gas.

Calculations:

Year	Generator Destruction (cfm)	Flare Capacity (cfm)	Flare Destruction (cfm)	Deduction (cfm)	Project Reductions (cfm)
2005	900	1000	0	1000	-100 (0)
2006	1400	1000	0	1000	400
2007	1800	1000	300	700	1100

Note: this example and the calculations are significantly simplified for illustrative purposes. The example values are calculated on a cubic feet per minute of landfill gas basis. Reporters are actually required to report the cumulative value of methane gas sent to the destruction device for each time interval t.

5.2 Quantifying Project Emissions

Project emissions must be quantified at a minimum on an annual, *ex-post* basis. As shown in Equation 5.9, project emissions equal:

- Total indirect carbon dioxide emissions resulting from consumption of electricity from the grid related to project activities
- Total carbon dioxide emissions from the on-site destruction of fossil fuel related to project activities
- Total carbon dioxide emissions from the combustion of supplemental natural gas
- Total methane emissions from the incomplete combustion of supplemental natural gas

Project emissions shall be calculated using Equation 5.9.

Equation 5.9. Calculating Project Emissions

$$PE = FF_{CO_2} + EL_{CO_2} + NG_{PR}$$

Where,			Units
PE	=	Project emissions during the reporting period	tCO_2e
FF_{CO2}	=	Total carbon dioxide emissions from the destruction of fossil fuel during the reporting period	tCO_2
EL_{CO2}	=	Total carbon dioxide emissions from the consumption of electricity from the grid during the reporting period	tCO_2
NG_{PR}	=	Total quantity of emissions from supplemental natural gas, including both uncombusted methane and carbon dioxide emissions during the reporting period	tCO_2

Equation 5.10. Calculating Project Emissions from Fossil Fuel Use

$$FF_{CO_2} = \frac{\sum_j \left(FF_{PR,j} \times EF_{FF,j}\right)}{1000}$$

Where,			Units
FF_{CO2}	=	Total carbon dioxide emissions from the destruction of fossil fuel during the reporting period	tCO_2
$FF_{PR,j}$	=	Total fossil fuel consumed by the project landfill gas collection and destruction system during the reporting period, by fuel type j	volume fossil fuel
$EF_{FF,j}$	=	Fuel specific emission factor. See Appendix C	$kgCO_2$/ volume fossil fuel
1000	=	Conversion factor	$kgCO_2$/ tCO_2

Equation 5.11. Calculating Project Emissions from Electricity Use

$$EL_{CO_2} = \frac{\left(EL_{PR} \times EF_{EL}\right)}{2204.62}$$

Where, Units

EL_{CO2}	=	Total carbon dioxide emissions from the consumption of electricity from the grid during the reporting period	tCO_2
EL_{PR}	=	Total electricity consumed by the project landfill gas collection and destruction system during the reporting period	MWh
EF_{EL}	=	CO_2 emission factor for electricity used[25]	$lbCO_2$/ MWh
2204.62	=	Conversion factor	$lbCO_2$/ tCO_2

Equation 5.12. Calculating Project Emissions from the Use of Supplemental Natural Gas

$$NG_{PR} = \sum_i \left[NG_i \times NG_{CH4} \times 0.0423 \times 0.000454 \times \left[\left(\left(1 - DE_i\right) \times 21 \right) + \left(DE_i \times \frac{12}{16} \times \frac{44}{12} \right) \right] \right]$$

Where, Units

NG_{PR}	=	Total emissions from supplemental natural gas during the reporting period, including both uncombusted methane and carbon dioxide emissions	tCO_2e
NG_i	=	Total quantity of supplemental natural gas delivered to the destruction device i during the reporting period	scf
DE_i	=	Methane destruction efficiency of destruction device i. See Appendix C	
NG_{CH4}	=	Average methane fraction of the supplemental natural gas as provided for by fuel vendor	scf CH_4/ scf NG
0.0423	=	Density of methane	$lbCH_4$/ scf CH_4
0.000454	=	Conversion factor	tCH_4/ $lbCH_4$
21	=	Global Warming Potential factor of methane to carbon dioxide equivalent	
12/16	=	Carbon ratio of methane	C/CH_4
44/12	=	Carbon ratio of carbon dioxide	CO_2/C

[25] Refer to the most version of the U.S. EPA eGRID most closely corresponding to the time period during which the electricity was used. Projects shall use the annual total output emission rates for the subregion where the project is located, not the annual non-baseload output emission rates. The eGRID tables are available from the U.S. EPA website: http://www.epa.gov/cleanenergy/energy-resources/egrid/index.html.

6 Project Monitoring

The Reserve requires a Monitoring Plan to be established for all monitoring and reporting activities associated with the project. The Monitoring Plan will serve as the basis for verifiers to confirm that the stipulations of this section and Section 7 have been and will continue to be met, and that consistent, rigorous monitoring and record-keeping is ongoing at the project site. The Monitoring Plan must cover all aspects of monitoring and reporting contained in this protocol and must specify how data for all relevant parameters in Table 6.1 (below) will be collected and recorded.

At a minimum the Monitoring Plan shall stipulate the frequency of data acquisition; a record keeping plan (see Section 7.2 for minimum record keeping requirements); the frequency of instrument cleaning, inspection, field check and calibration activities; and the role of the individual performing each specific monitoring activity, as well as QA/QC provisions to ensure that data acquisition and meter calibration are carried out consistently and with precision. The Monitoring Plan shall also contain a detailed diagram of the landfill gas collection and destruction system, including the placement of all meters and equipment that affect SSRs within the GHG Assessment Boundary (see Figure 4.1).

Finally, the Monitoring Plan must include procedures that the project developer will follow to ascertain and demonstrate that the project at all times passes the Legal Requirement Test (Section 3.4.2).

Project developers are responsible for monitoring the performance of the project and operating the landfill gas collection and destruction system in a manner consistent with the manufacturer's recommendations for each component of the system.

6.1 Monitoring Requirements

Methane emission reductions from landfill gas capture and control systems must be monitored with measurement equipment that directly meters:

- The flow of landfill gas delivered to each destruction device[26], measured continuously and recorded every 15 minutes or totalized and recorded at least daily, adjusted for temperature and pressure

- The fraction of methane in the landfill gas delivered to the destruction device, measured continuously and recorded every 15 minutes and averaged at least daily (measurements taken at a frequency that is between daily and weekly may be used with the application of a 10% discount in Equation 5.3)

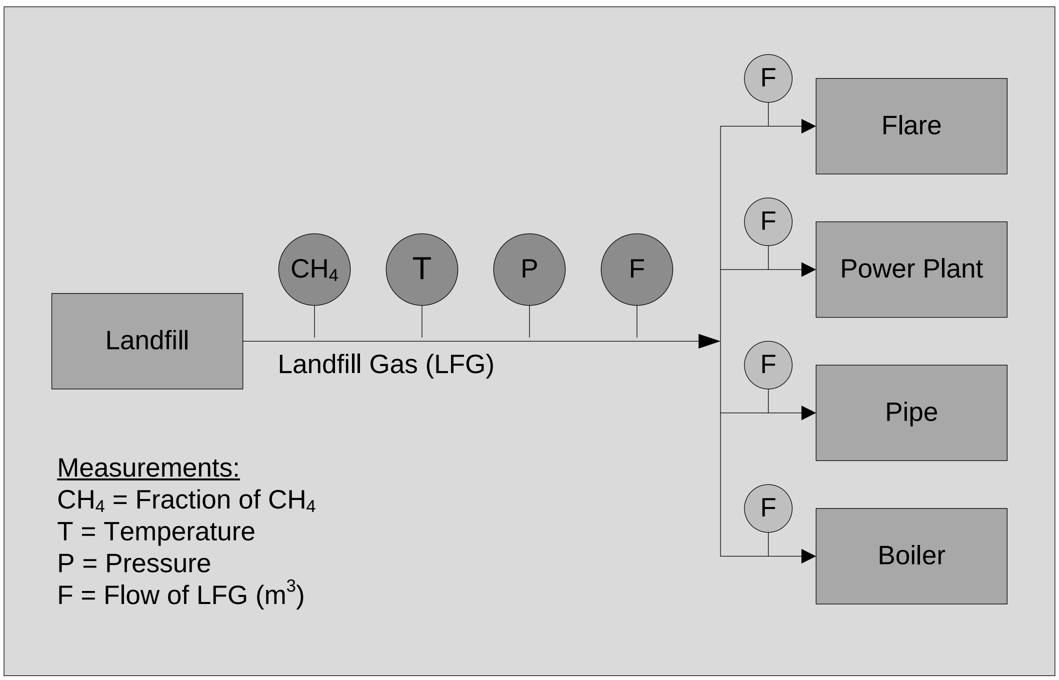
All flow data collected must be corrected for temperature and pressure at 60^{o} F and 1 atm. If any of the landfill gas flow metering equipment does not internally correct for the temperature and pressure of the landfill gas, separate pressure and temperature measurements must be used to correct the flow measurement. The temperature and pressure of the landfill gas must be measured continuously. Corrected values must be used in all of the equations of this section.

[26] A single meter may be used for multiple, identical destruction devices. In this instance, methane destruction in these units will be eligible only if both units are monitored to be operational.

Apply Equation 5.2 only if the landfill gas flow metering equipment does not internally correct for temperature and pressure.

The continuous methane analyzer should be the preferred option for monitoring methane concentrations, as the methane content of landfill gas captured can vary by more than 20% during a single day due to gas capture network conditions (dilution with air at wellheads, leakage on pipes, etc.).[27, 28] When using the alternative approach of weekly methane concentration measurement using a calibrated portable gas analyzer, project developers must account for the uncertainty associated with these measurements by applying a 10% discount factor to the total quantity of methane collected and destroyed in Equation 5.3.

Figure 6.1 represents the suggested arrangement of the landfill gas flow meters and methane concentration metering equipment.



Note: The number of flow meters must be sufficient to track the total flow as well as the flow to each combustion device. The above scenario includes one more flow meter than would be necessary to achieve this objective.
Source: Consolidated baseline methodology for landfill gas project activities, Clean Development Mechanism, Version 07, Sectoral Scope 13 (2007).

Figure 6.1. Suggested Arrangement of LFG Metering Equipment

Eligible projects may use monthly methane concentration measurements using a calibrated portable gas analyzer until January 1, 2009, after which a continuous methane analyzer or

[27] Methane fraction of the landfill gas to be measured on a wet/dry basis (must be measured on same basis as flow, temperature, and pressure). The methane analyzer and flow meter should be installed in the same relative placement to any moisture-removing components of the landfill gas system (there should not be a moisture-removing component separating the measurement of flow and methane fraction). An acceptable variation to this arrangement would be in the case where the flow meter is placed after a moisture-removing component (dry basis), while the methane analyzer is placed before this component (wet basis). The opposite arrangement is not permissible. No separate monitoring of temperature and pressure is necessary when using flow meters that automatically correct for temperature and pressure, expressing LFG volumes in normalized cubic meters.
[28] Consolidated baseline methodology for landfill gas project activities, Clean Development Mechanism, Version 07, Sectoral Scope 13 (2007).

weekly measurement using a calibrated portable gas analyzer is required. In the case where monthly methane concentration measurements are used, project developers must account for the uncertainty associated with these measurements by applying a 20% discount factor to the total quantity of methane collected and destroyed.

The operational activity of the landfill gas collection system and the destruction devices shall be monitored and documented at least hourly to ensure actual landfill gas destruction. GHG reductions will not be accounted for during periods which the destruction device was not operational. For flares, operation is defined as thermocouple readings above 500° F. For all other destruction devices, the means of demonstration shall be determined by the project developer and subject to verifier review.

6.2 Instrument QA/QC

Monitoring instruments shall be inspected and calibrated according to the following schedule.

All gas flow meters[29] and continuous methane analyzers must be:

- Cleaned and inspected on a regular basis, as specified in the project's Monitoring Plan, with activities and results documented by site personnel. Cleaning and inspection frequency must, at a minimum, follow the manufacturer's recommendations.
- Field checked for calibration accuracy by a third-party technician with the percent drift documented, using either a portable instrument (such as a pitot tube) or manufacturer specified guidance, at the end of – but no more than two months prior to or after – the end date of the reporting period[30]
- Calibrated by the manufacturer or a certified third-party calibration service per manufacturer's guidance or every 5 years, whichever is more frequent

If the required calibration or calibration check is not performed and properly documented, no GHG credits may be generated for that reporting period. Flow meter calibrations shall be documented to show that the meter was calibrated to a range of flow rates corresponding to the flow rates expected at the landfill. Methane analyzer calibrations shall be documented to show that the calibration was carried out to the range of conditions (temperature and pressure) corresponding to the range of conditions as measured at the landfill.

If the field check on a piece of equipment reveals accuracy outside of a +/- 5% threshold, calibration by the manufacturer or a certified service provider is required for that piece of equipment.

For the interval between the last successful field check and any calibration event confirming accuracy outside of the +/- 5% threshold, all data from that meter or analyzer must be scaled according to the following procedure. These adjustments must be made for the entire period from the last successful field check until such time as the meter is properly calibrated.

[29] Field checks and calibrations of flow meters shall ensure that the meter accurately reads volumetric flow, and has not drifted outside of the prescribed +/-5% accuracy threshold.

[30] Instead of performing field checks, the project developer may instead have equipment calibrated by the manufacturer or a certified calibration service per manufacturer's guidance, at the end of but no more than two months prior to or after the end date of the reporting period to meet this requirement.

1. For calibrations that indicate under-reporting (lower flow rates, or lower methane concentration), the metered values must be used without correction.

2. For calibrations that indicate over-reporting (higher flow rates, or higher methane concentration), the metered values must be adjusted based on the greatest calibration drift recorded at the time of calibration.

For example, if a project conducts field checks quarterly during a year-long reporting period, then only three months of data will be subject at any one time to the penalties above. However, if the project developer feels confident that the meter does not require field checks or calibration on a greater than annual frequency, then failed events will accordingly require the penalty to be applied to the entire year's data. Frequent calibration may minimize the total accrued drift (by zeroing out any error identified), and result in smaller overall deductions. Additionally, strong equipment inspection practices that include checking all probes and internal components will minimize the risk of meter and analyzer inaccuracies and the corresponding deductions.

In order to provide flexibility in verification, data monitored up to two months after a field check may be verified. As such, the end date of the reporting period must be no more than two months after the latest successful field check.

If a portable instrument is used (such as a handheld methane analyzer), the portable instrument shall be maintained and calibrated per the manufacturer's specifications, and calibrated at least annually by the manufacturer, by a laboratory approved by the manufacturer, or at an ISO 17025 accredited laboratory. The portable instrument also must be field calibrated to a known sample gas prior to each use.

If available, the official source tested methane destruction efficiency shall be used in Equation 5.4 in place of the default methane destruction efficiency. Otherwise, project developers have the option to use either the default methane destruction efficiencies provided, or the site specific methane destruction efficiencies as provided by a state or local agency accredited source test service provider, for any of the destruction devices used in the project, performed on an annual basis. Device-specific source testing shall include at least three test runs, with the accepted final value being one standard deviation below the mean of the measured efficiencies.

6.3 Missing Data

In situations where the flow rate or methane concentration monitoring equipment is missing data, the project developer shall apply the data substitution methodology provided in Appendix E. If for any reason the destruction device monitoring equipment is inoperable (for example, the thermal coupler on the flare), then no emission reductions can be registered for the period of inoperability.

6.4 Monitoring Parameters

Prescribed monitoring parameters necessary to calculate baseline and project emissions are provided in Table 6.1.

Table 6.1. Monitoring Data to be Collected and Used to Estimate Emission Reductions

Eq. #	Parameter	Description	Data Unit	Measurement Frequency	Calculated (c) Measured (m) Reference (r) Operating records (o)	Comment
		Amount of waste in place	metric tons	Annually, or Each reporting period	o	Must be monitored and determined for each reporting period. The amount of waste in place shall be documented as of the beginning of the reporting period to assess whether the landfill continues to satisfy the performance standard test (Section 3.4.1). For landfills that are required by a regulatory agency to submit an annual WIP report, the most recent of these reports as of the beginning of the reporting period may be used
		Legal Requirement Test	Project developer attestation to compliance with regulatory requirements relating to landfill gas project	Each reporting period		Must be monitored and determined for each project period. The project developer shall document all federal, state, and local regulations, ordinances, and permit requirements (and compliance status for each) that apply to the GHG reduction project. The project developer shall provide a signed attestation to their compliance status for the above mentioned federal, state, and local regulations, ordinances, and permit requirements
		Operation of destruction device		Hourly	o	Required for each destruction device. For flares, operation is defined as thermocouple readings above 500° F
Equation 5.1	ER	GHG emission reductions during the reporting period	tCO_2e		c	

Eq. #	Parameter	Description	Data Unit	Measurement Frequency	Calculated (c) Measured (m) Reference (r) Operating records (o)	Comment
Equation 5.1 Equation 5.3	BE	Baseline emissions during the reporting period	tCO_2e		c	
Equation 5.1 Equation 5.9	PE	Project emissions during the reporting period	tCO_2e		c	
Equation 5.2 Equation 5.4	$LFG_{i,t}$	Adjusted volume of landfill gas fed to the destruction device i, in time interval t	scf	Continuous	m/c	Measured continuously by a flow meter and recorded at least once every 15 minutes. Data to be aggregated by time interval t (this parameter is calculated in cases where the metered flow must be corrected for temperature and pressure)
Equation 5.2	$LFG_{unadjusted}$	Unadjusted volume of landfill gas collected for the given time interval	acf	Continuous	m	Used only in cases where the flow meter does not automatically correct to 60° F and 1 atm
Equation 5.3 Equation 5.4	CH_4Dest_{PR}	Total methane destroyed by the project landfill gas collection and destruction system during the reporting period	tCH_4		c	
Equation 5.3	DF	Discount factor to account for uncertainties associated with the monitoring equipment	0-1.0		r	Equal to zero if using continuous methane monitor (see Section 6.1)

Eq. #	Parameter	Description	Data Unit	Measurement Frequency	Calculated (c) Measured (m) Reference (r) Operating records (o)	Comment
Equation 5.3	OX	Factor for the oxidation of methane by soil bacteria	0, 0.1		r	Equal to 0.10 for all landfills except those that incorporate a synthetic liner throughout the entire area of the final cover system where OX = 0
Equation 5.3 Equation 5.5	$Dest_{base}$	Adjustment to account for the baseline methane destruction associated with a baseline destruction device	tCO_2e		c	Equal to zero if no baseline LFG destruction system is in place prior to project implementation
Equation 5.4	CH_4Dest_i	The net quantity of methane destroyed by destruction device i during the reporting period	scf CH_4		c	
Equation 5.4	Q_i	Total quantity of landfill methane sent to destruction device i during the reporting period	scf CH_4	Daily/Weekly	c	Calculated daily if methane is continuously metered or weekly if methane is measured weekly
Equation 5.4 Equation 5.12	DE_i	Default methane destruction efficiency for device i	%	Once	r/m	Project developers have the option to use a state or local agency accredited source test service provider to test the actual methane destruction efficiency of each of the destruction devices used in the project case. If using source test data for destruction efficiencies in Equation 5.2, all source test documentation shall be provided to the verifier. See Appendix C for default values

Eq. #	Parameter	Description	Data Unit	Measurement Frequency	Calculated (c) Measured (m) Reference (r) Operating records (o)	Comment
Equation 5.4	t	Time interval for which LFG flow and concentration measurements are aggregated	week, day, or smaller interval	Continuous/ Daily/ Weekly	r	Projects employing continuous methane concentration monitoring may use the interval of their data acquisition system. Otherwise, this parameter is equal to one day for continuously monitored methane concentration and one week for weekly monitored methane concentration.
Equation 5.4 Equation 5.8	$PR_{CH4,t}$	The average methane fraction of the landfill gas in time interval t	scf CH_4 / scf LFG	Continuous/ Weekly	m	Measured by continuous gas analyzer or a calibrated portable gas analyzer. Data to be averaged by time interval t.
Equation 5.5 Equation 5.6	$Closed_{discount}$	Adjustment to account for the methane which would have been combusted in the baseline flare from baseline wells at a closed landfill	scf CH_4	Yearly	c	Calculated per year, but may be scaled for project reporting periods less than one year
Equation 5.5 Equation 5.7	$NQ_{discount}$	Adjustment to account for the methane which would have been combusted in the baseline, non-qualifying combustion device	scf CH_4	Yearly	c	Calculated per year, but may be scaled for project reporting periods less than one year
Equation 5.5 Equation 5.8	$Dest_{max}$	Deduction of the un-utilized capacity of the baseline destruction device	scf CH_4	Weekly, Monthly, or Per reporting period (no more than weekly)	c	This deduction is to be applied only when a new destruction device is used during project activity

Eq. #	Parameter	Description	Data Unit	Measurement Frequency	Calculated (c) Measured (m) Reference (r) Operating records (o)	Comment
Equation 5.6	LFG_{B1}	Landfill gas from the baseline landfill gas wells that would have been destroyed by the qualifying destruction system during the reporting period	scf LFG	Yearly	c	Calculated using Appendix D. Calculated per year, but may be scaled for project reporting periods less than one year
Equation 5.6	$B_{CH4,closed}$	Methane fraction of landfill gas destroyed by baseline flares at a closed landfill	scf CH_4 / scf LFG	Continuously/ Weekly	m	Measured by continuous gas analyzer or a calibrated portable gas analyzer.
Equation 5.7	LFG_{B2}	Landfill gas that would have been destroyed by the original, non-qualifying destruction system during the reporting period	scf LFG / yr	Yearly	c	Calculated per Section 5, or according to guidance provided in Appendix D. Calculated per year, but may be scaled for project reporting periods less than one year
Equation 5.7	$B_{CH4,NQ}$	Methane fraction of landfill gas destroyed by non-qualifying devices in the baseline	scf CH_4 / scf LFG	Continuously/ Weekly	m	Measured by continuous gas analyzer or a calibrated portable gas analyzer
Equation 5.8	$LFG_{Bmax,t}$	The maximum landfill gas flow capacity of the baseline methane destruction device in time interval t	scf	At beginning of first reporting period	c	Calculated based on manufacturer’s and/or engineers specifications for the destruction device and blower system. The maximum capacity of the limiting component, either the destruction device or blower, shall be used

Eq. #	Parameter	Description	Data Unit	Measurement Frequency	Calculated (c) Measured (m) Reference (r) Operating records (o)	Comment
Equation 5.8	$LFG_{B3,t}$	The actual landfill gas flow of the baseline methane destruction device in time interval t	scf	Continuous	m	Measured continuously by a flow meter and recorded at least once every 15 minutes
Equation 5.9 Equation 5.10	FF_{CO2}	Total carbon dioxide emissions from the destruction of fossil fuel during the reporting period	tCO_2	Per reporting period	c	
Equation 5.9 Equation 5.11	EL_{CO2}	Total carbon dioxide emissions from the consumption of electricity from the grid during the reporting period	tCO_2		c	
Equation 5.9 Equation 5.12	NG_{PR}	Total quantity of emissions from supplemental natural gas, including both uncombusted methane and carbon dioxide emissions during the reporting period	tCO_2	Per reporting period	c	Includes both uncombusted methane and carbon dioxide emissions

Eq. #	Parameter	Description	Data Unit	Measurement Frequency	Calculated (c) Measured (m) Reference (r) Operating records (o)	Comment
Equation 5.10	$FF_{PR,j}$	Total fossil fuel consumed by the project landfill gas collection and destruction system during the reporting period, by fuel type j	volume fossil fuel	Monthly	o	Calculated from monthly record of fossil fuel purchased and consumed
Equation 5.10	$EF_{FF,j}$	Fuel specific emission factor	kg CO_2 / volume fossil fuel	Per reporting period	r	See Appendix C
Equation 5.11	EL_{PR}	Total electricity consumed by the project landfill gas collection and destruction system during the reporting period	MWh		m/o	Obtained from either onsite metering or utility purchase records. Required to determine CO_2 emissions from use of electricity to operate the project activity
Equation 5.11	EF_{EL}	Carbon emission factor for electricity used	lbCO_2 / MWh	Per reporting period	r	See the most up to date version available of the U.S. EPA eGRID. http://www.epa.gov/cleanenergy/energy-resources/egrid/index.html
Equation 5.12	NG_i	Total quantity of supplemental natural gas delivered to the destruction device i during the reporting period	scf	Continuous	m	Metered prior to delivery to destruction device

Eq. #	Parameter	Description	Data Unit	Measurement Frequency	Calculated (c) Measured (m) Reference (r) Operating records (o)	Comment
Equation 5.12	NG_{CH4}	Average methane fraction of the supplemental natural gas as provided for by fuel vendor	scf CH_4 / scf NG		r	Refer to purchase records
	T	Temperature of the landfill gas	°C	Continuous	m	No separate monitoring of temperature is necessary when using flow meters that automatically adjust flow volumes for temperature and pressure, expressing LFG volumes in normalized cubic feet
	P	Pressure of the landfill gas	atm	Continuous	m	No separate monitoring of pressure is necessary when using flow meters that automatically measure adjust flow volumes for temperature and pressure, expressing LFG volumes in normalized cubic feet

7 Reporting Parameters

This section provides guidance on reporting rules and procedures. A priority of the Reserve is to facilitate consistent and transparent information disclosure among project developers. Project developers must submit verified emission reduction reports to the Reserve annually at a minimum.

7.1 Project Documentation

Project developers must provide the following documentation to the Reserve in order to register a landfill gas destruction project:

- Project Submittal form
- Signed Attestation of Title form
- Signed Attestation of Voluntary Implementation form
- Signed Attestation of Regulatory Compliance form
- Detailed system diagram from Monitoring Plan
- Verification Report
- Verification Opinion

Project developers must provide the following documentation each reporting period in order for the Reserve to issue CRTs for quantified GHG reductions:

- Verification Report
- Verification Opinion
- Signed Attestation of Title form
- Signed Attestation of Voluntary Implementation form
- Signed Attestation of Regulatory Compliance form

At a minimum, the above project documentation will be available to the public via the Reserve's online reporting tool of the same name, the Climate Action Reserve. Further disclosure and other documentation may be made available on a voluntary basis. Project submittal forms and project registration information can be found at: http://www.climateactionreserve.org/how/projects/register/project-submittal-forms/.

7.2 Record Keeping

For purposes of independent verification and historical documentation, project developers are required to keep all information outlined in this protocol for a period of 10 years after the information is generated or 7 years after the last verification. This information will not be publicly available, but may be requested by the verifier or the Reserve.

System information the project developer should retain includes:

- All data inputs for the calculation of GHG reductions
- Copies of all solid waste, air, water, and land use permits; Notices of Violations (NOVs); and any administrative or legal consent orders dating back at least 3 years prior to the project start date, and for each subsequent year of project operation
- Project developer attestation of compliance with regulatory requirements relating to the landfill gas project
- Collection and control device information (installation dates, equipment list, etc.)

- LFG flow meter information (model number, serial number, manufacturer's calibration procedures)
- Methane monitor information (model number, serial number, calibration procedures)
- Destruction device monitor information (model number, serial number, calibration procedures)
- LFG flow data (for each flow meter)
- LFG flow meter calibration data (for each flow meter)
- Methane monitoring data
- Methane monitor calibration data
- Destruction device monitoring data (for each destruction device)
- Destruction device monitor calibration data (for each destruction device)
- CO_2e monthly and annual tonnage calculations
- Copies of the results of the NSPS/EG Tier 1 and/or Tier 2 NMOC emission rate estimates and the projected date when system start-up will be required by NSPS
- Initial and annual verification records and results
- All maintenance records relevant to the LFG control system, monitoring equipment, and destruction devices
- Operational records of the landfill relating to the amount of waste placed on site (scalehouse records, etc.), or most recent documented WIP report accepted by a regulatory agency

Calibrated portable gas analyzer information that the project developer should retain includes:

- Date, time, and location of methane measurement
- Methane content of LFG (% by volume) for each measurement
- Methane measurement instrument type and serial number
- Date, time, and results of instrument calibration
- Corrective measures taken if instrument does not meet performance specifications

7.3 Reporting Period and Verification Cycle

Project developers must report GHG reductions resulting from project activities during each reporting period. Although projects must be verified annually at a minimum, the Reserve will accept verified emission reduction reports on a sub-annual basis, should the project developer choose to have a sub-annual reporting period and verification schedule (e.g. quarterly or semi-annually). A reporting period cannot exceed 12 months, and no more than 12 months of emission reductions can be verified at once, except during a project's first verification, which may include historical emission reductions from prior years.

Reporting periods must be contiguous; there may be no time gaps in reporting during the crediting period of a project once the initial reporting period has commenced.

8 Verification Guidance

This section provides verification bodies with guidance on verifying GHG emission reductions from landfill gas projects developed to the standards of this protocol. This verification guidance supplements the Reserve's Verification Program Manual and describes verification activities in the context of landfill gas destruction projects.

Verification bodies trained to verify landfill gas projects must conduct verifications to the standards of the following documents:

- Climate Action Reserve Program Manual
- Climate Action Reserve Verification Program Manual
- Climate Action Reserve Landfill Project Protocol

The Reserve's Program Manual, Verification Program Manual, and project protocols are designed to be compatible with each other and are available on the Reserve's website at http://www.climateactionreserve.org.

In cases where the Program Manual and/or Verification Program Manual differ from the guidance in this protocol, this protocol takes precedent.

Only ISO-accredited verification bodies trained by the Reserve for this project type are eligible to verify landfill project reports. Verification bodies approved under other project protocol types are not permitted to verify landfill projects. Information about verification body accreditation and Reserve project verification training can be found in the Verification Program Manual.

8.1 Standard of Verification

The Reserve's standard of verification for landfill projects is the Landfill Project Protocol (this document), the Reserve Program Manual, and the Verification Program Manual. To verify a landfill project developer's project report, verification bodies apply the guidance in the Verification Program Manual and this section of the protocol to the standards described in Section 2 through 7 of this protocol. Sections 2 through 7 provide eligibility rules, methods to calculate emission reductions, performance monitoring instructions and requirements, and procedures for reporting project information to the Reserve.

8.2 Monitoring Plan

The Monitoring Plan serves as the basis for verification bodies to confirm that the monitoring and reporting requirements in Section 6 and Section 7 have been met, and that consistent, rigorous monitoring and record-keeping is ongoing at the project site. Verification bodies shall confirm that the Monitoring Plan covers all aspects of monitoring and reporting contained in this protocol and specifies how data for all relevant parameters in Table 6.1 are collected and recorded.

8.3 Verifying Project Eligibility

Verification bodies must affirm a landfill project's eligibility according to the rules described in this protocol. The table below outlines the eligibility criteria for a landfill project. This table does not represent all criteria for determining eligibility comprehensively; verification bodies must also look to Section 3 and the verification items list in Table 8.2.

Table 8.1. Summary of Eligibility Criteria

Eligibility Rule	Eligibility Criteria	Frequency of Rule Application
Start Date	Projects must be submitted for listing within 6 months of the project start date	Once during first verification
Location	United States and its territories	Once during first verification
Performance Standard: Practice Threshold	Installation of a qualifying destruction device where not required by law (see Section 3.4.1 for other requirements)	Once during first verification
Performance Standard: Size Threshold	Landfills whose landfill gas destruction results in energy generation must have a waste in place no greater than 2.17 MMT for arid counties and 0.72 MMT for non-arid counties	Every verification
Legal Requirement Test	Signed Attestation of Voluntary Implementation form and monitoring procedures that lay out procedures for ascertaining and demonstrating that the project passes the Legal Requirement Test	Every verification
Regulatory Compliance Test	Signed Attestation of Regulatory Compliance form and disclosure of all non-compliance events to verifier; project must be in material compliance with all applicable laws	Every verification
Exclusions	▪ Bioreactors ▪ Landfills which re-circulate a liquid other than leachate in a controlled manner ▪ Indirect emissions from the displacement of grid electricity or natural gas	Every verification

8.4 Core Verification Activities

The Landfill Project Protocol provides explicit requirements and guidance for quantifying GHG reductions associated with the destruction of landfill methane. The Verification Program Manual describes the core verification activities that shall be performed by verification bodies for all project verifications. They are summarized below in the context of a landfill project, but verification bodies shall also follow the general guidance in the Verification Program Manual.

Verification is a risk assessment and data sampling effort designed to ensure that the risk of reporting error is assessed and addressed through appropriate sampling, testing, and review. The three core verification activities are:

1. Identifying emissions sources, sinks and reservoirs
2. Reviewing GHG management systems and estimation methodologies
3. Verifying emission reduction estimates

Identifying emission sources, sinks, and reservoirs

The verification body reviews for completeness the sources, sinks, and reservoirs identified for a project, such as system energy use, fuel consumption, combustion and destruction from various qualifying and non-qualifying destruction devices, and soil oxidation.

Reviewing GHG management systems and estimation methodologies
The verification body reviews and assesses the appropriateness of the methodologies and management systems that the landfill project uses to gather data on methane collected and destroyed and to calculate baseline and project emissions.

Verifying emission reduction estimates
The verification body further investigates areas that have the greatest potential for material misstatements and then confirms whether or not material misstatements have occurred. This involves site visits to the project to ensure the systems on the ground correspond to and are consistent with data provided to the verification body. In addition, the verification body recalculates a representative sample of the performance or emissions data for comparison with data reported by the project developer in order to double-check the calculations of GHG emission reductions.

8.5 Landfill Project Verification Items

The following tables provide lists of items that a verification body needs to address while verifying a landfill project. The tables include references to the section in the protocol where requirements are further described. The table also identifies items for which a verification body is expected to apply professional judgment during the verification process. Verification bodies are expected to use their professional judgment to confirm that protocol requirements have been met in instances where the protocol does not provide (sufficiently) prescriptive guidance. For more information on the Reserve’s verification process and professional judgment, please see the Verification Program Manual.

Note: These tables shall not be viewed as a comprehensive list or plan for verification activities, but rather guidance on areas specific to landfill projects that must be addressed during verification.

8.5.1 Project Eligibility and CRT Issuance

Table 8.2 lists the criteria for reasonable assurance with respect to eligibility and CRT issuance for landfill projects. These requirements determine if a project is eligible to register with the Reserve and/or have CRTs issued for the reporting period. If any one requirement is not met, either the project may be determined ineligible or the GHG reductions from the reporting period (or sub-set of the reporting period) may be ineligible for issuance of CRTs, as specified in Sections 2, 3, and 6.

Table 8.2. Eligibility Verification Items

Protocol Section	Eligibility Qualification Item	Apply Professional Judgment?
2.2	Verify that the project meets the definition of a landfill project and is properly defined per Section 2.2	No
2.3	Verify ownership of the reductions by reviewing Attestation of Title	No
2.3	For direct use agreements between the project developer and the end user of the landfill gas (i.e. an industrial client purchasing the landfill gas from the project developer), verify that a legally binding mechanism is built into the agreement language to assure that the GHG offset credits will not be double counted	No
3.2	Verify eligibility of project start date	No
3.2	Verify accuracy of project start date based on operational records	Yes
3.3	Verify that project is within its 10 year crediting period	No

Protocol Section	Eligibility Qualification Item	Apply Professional Judgment?
3.4.1	Verify that the project meets the appropriate Performance Standard Tests for the project type per Section 3.4.1	No
3.4.2	Confirm execution of the Attestation of Voluntary Implementation form to demonstrate eligibility under the Legal Requirement Test	No
3.4.2	Verify that the project activities comply with applicable laws by reviewing any instances of non-compliance provided by the project developer and performing a risk-based assessment to confirm the statements made by the project developer in the Attestation of Regulatory Compliance form	Yes
4	Confirm all baseline non-qualifying devices have been properly accounted for within project's GHG Assessment Boundary	No
4	Confirm all baseline qualifying devices have been properly accounted for within project's GHG Assessment Boundary	No
6	Verify that monitoring meets the requirements of the protocol. If it does not, verify that a variance has been approved for monitoring variations	No
6	Verify that the project monitoring plan contains procedures for ascertaining and demonstrating that the project passes the Legal Requirement Test at all times	Yes
6	Verify that the landfill gas control system operated in a manner consistent with the design specifications	Yes
6	Verify that there is an individual responsible for managing and reporting GHG emissions, and that individual properly trained and qualified to perform this function	Yes
6.2	Verify that all gas flow meters and methane analyzers adhered to the inspection, cleaning, and calibration schedule specified in the protocol. If they do not, verify that a variance has been approved for monitoring variations or that adjustments have been made to data per the protocol requirements	No
6.2	If any piece of equipment failed a calibration check, verify that data from that equipment was scaled according to the failed calibration procedure for the appropriate time period	No
6.3	If used, verify that data substitution methodology was properly applied	No
7.1	Verify that appropriate documents are created to support and/or substantiate activities related to GHG emission reporting activities, and that such documentation is retained appropriately	Yes
	If any variances were granted, verify that variance requirements were met and properly applied	Yes

8.5.2 Quantification of GHG Emission Reductions

Table 8.3 lists the items that verification bodies shall include in their risk assessment and re-calculation of the project's GHG emission reductions. These quantification items inform any determination as to whether there are material and/or immaterial misstatements in the project's GHG emission reduction calculations. If there are material misstatements, the calculations must be revised before CRTs are issued.

Table 8.3. Quantification Verification Items

Protocol Section	Quantification Item	Apply Professional Judgment?
4	Verify that SSRs included in the GHG Assessment Boundary correspond to those required by the protocol and those represented in the project	No
5	Verify that the project developer correctly accounted for baseline methane destruction in the baseline scenario	No
5	Verify that the project developer correctly monitored, quantified and aggregated the amount of methane collected from the landfill and destroyed by the project landfill gas control system?	No
5	Verify that the project developer correctly quantified and aggregated electricity use	Yes
5	Verify that the project developer correctly quantified and aggregated fossil fuel use	Yes
5	Verify that the project developer applied the correct emission factors for fossil fuel combustion and grid-delivered electricity	No
5	Verify that the project developer applied the correct methane destruction efficiencies	No
Appendix C	If the project developer used source test data in place of the default destruction efficiencies (Appendix C), verify accuracy and appropriateness of data and calculations	Yes

8.5.3 Risk Assessment

Verification bodies will review the following items in Table 8.4 to guide and prioritize their assessment of data used in determining eligibility and quantifying GHG emission reductions.

Table 8.4. Risk Assessment Verification Items

Protocol Section	Item that Informs Risk Assessment	Apply Professional Judgment?
6	Verify that the project monitoring plan is sufficiently rigorous to support the requirements of the protocol and proper operation of the project	Yes
6	Verify that appropriate monitoring equipment is in place to meet the requirements of the protocol	No
6	Verify that equipment calibrations have been carried out to satisfy the requirements of the protocol	No
6	Verify that the individual or team responsible for managing and reporting project activities are qualified to perform this function	Yes
6	Verify that appropriate training was provided to personnel assigned to greenhouse gas reporting duties	Yes
6	Verify that all contractors are qualified for managing and reporting greenhouse gas emissions if relied upon by the project developer. Verify that there is internal oversight to assure the quality of the contractor’s work	Yes
6.2	Verify that the methane destruction equipment was operated and maintained according to manufacturer specifications	Yes
7.2	Verify that all required records have been retained by the project developer	No

8.6 Completing Verification

The Verification Program Manual provides detailed information and instructions for verification bodies to finalize the verification process. It describes completing a Verification Report, preparing a Verification Opinion, submitting the necessary documents to the Reserve, and notifying the Reserve of the project's verified status.

9 Glossary of Terms

Accredited verification body	A verification firm approved by the Climate Action Reserve to provide verification services for project developers.
Additionality	Landfill management practices that are above and beyond business-as-usual operation, exceed the baseline characterization, and are not mandated by regulation.
Anaerobic	Pertaining to or caused by the absence of oxygen.
Anthropogenic emissions	GHG emissions resultant from human activity that are considered to be an unnatural component of the Carbon Cycle (i.e. fossil fuel destruction, de-forestation, etc.).
Biogenic CO_2 emissions	CO_2 emissions resulting from the destruction and/or aerobic decomposition of organic matter. Biogenic emissions are considered to be a natural part of the Carbon Cycle, as opposed to anthropogenic emissions.
Bioreactor	Any landfill which: a. Meets the EPA definition of a bioreactor: “a MSW landfill or portion of a MSW landfill where any liquid other than leachate (leachate includes landfill gas condensate) is added in a controlled fashion into the waste mass (often in combination with recirculating leachate) to reach a minimum average moisture content of at least 40 percent by weight to accelerate or enhance the anaerobic (without oxygen) biodegradation of the waste.”[31] b. Has been designated by local, state, or federal regulators as a bioreactor. c. Has received grants or funding to operate as a bioreactor.
Carbon dioxide (CO_2)	The most common of the six primary greenhouse gases, consisting of a single carbon atom and two oxygen atoms.
Closed landfill	A landfill that has ceased waste acceptance, and has submitted a closure report to EPA or the state indicating that it will no longer accept waste.
CO_2 equivalent (CO_2e)	The quantity of a given GHG multiplied by its total global warming potential. This is the standard unit for comparing the degree of warming which can be caused by different GHGs.
Direct emissions	Greenhouse gas emissions from sources that are owned or controlled by the reporting entity.
Eligible landfill	An “eligible landfill” is a landfill that: 1. Is not subject to regulations or other legal requirements requiring the destruction of methane gas 2. Is not a bioreactor 3. Does not add any liquid other than leachate into the waste mass in a controlled manner

[31] 40 CFR 63.1990 and 40 CFR 258.28a.

Emission factor (EF)	A unique value for determining an amount of a greenhouse gas emitted for a given quantity of activity data (e.g. metric tons of carbon dioxide emitted per barrel of fossil fuel burned).
Emission guidelines (EG)	Guidelines for State regulatory plans that have been developed by the U.S. EPA. For landfills, emission guidelines are codified in 40 CFR 60 Subpart Cc.
Flare	A destruction device that uses an open flame to burn combustible gases with combustion air provided by uncontrolled ambient air around the flame.
Fossil fuel	A fuel, such as coal, oil, and natural gas, produced by the decomposition of ancient (fossilized) plants and animals.
Greenhouse gas (GHG)	Carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), sulfur hexafluoride (SF_6), hydrofluorocarbons (HFCs), or perfluorocarbons (PFCs).
Global warming potential (GWP)	The ratio of radiative forcing (degree of warming to the atmosphere) that would result from the emission of one unit of a given GHG compared to one unit of CO_2.
Indirect emissions	Emissions that are a consequence of the actions of a reporting entity, but are produced by sources owned or controlled by another entity.
Landfill	A defined area of land or excavation that receives or has previously received waste that may include household waste, commercial solid waste, non-hazardous sludge and industrial solid waste.
Landfill gas (LFG)	Gas resulting from the decomposition of wastes placed in a landfill. Typically, landfill gas contains methane, carbon dioxide and other trace organic and inert gases.
Landfill gas project	Installation of infrastructure that in operating causes a decrease in GHG emissions through destruction of the methane component of landfill gas.
Landfill gas-to-energy (LFGE)	A LFGE project is one where the LFG destruction involves a destruction device that generates saleable energy (engine, turbine, microturbine, fuel cell, boiler, upgrade to pipeline, upgrade to CNG/LNG, etc.). This does not include small-scale, non-commercial applications, such as leachate drying.
Metric ton or “tonne” (MT)	A common international measurement for the quantity of GHG emissions, equivalent to about 2204.6 pounds or 1.1 short tons.
Methane (CH_4)	A potent GHG with a GWP of 21, consisting of a single carbon atom and four hydrogen atoms.
MMBtu	One million British thermal units.
Mobile combustion	Emissions from the transportation of materials, products, waste, and employees resulting from the combustion of fuels in company owned

	or controlled mobile combustion sources (e.g. cars, trucks, tractors, dozers, etc.).
National Emission Standards for Hazardous Air Pollutants (NESHAP)	Federal emission control standards codified in 40 CFR 63. Subpart AAAA of Part 63 prescribes emission limitations for MSW landfills.
New Source Performance Standards (NSPS)	Federal emission control standards codified in 40 CFR 60. Subpart WWW of Part 60 prescribes emission limitations for MSW landfills.
Non-methane organic compounds (NMOC)	Non-methane organic compounds as measured according to the provisions of 40 CFR 60.754.
Non-qualifying destruction device	A passive flare or other combustion system that results in the destruction of methane, but which cannot serve as the primary destruction device for a methane destruction project under this protocol.
Nitrous oxide (N_2O)	A GHG consisting of two nitrogen atoms and a single oxygen atom.
Project baseline	A business-as-usual GHG emission assessment against which GHG emission reductions from a specific GHG reduction activity are measured.
Project developer	An entity that undertakes a project activity, as identified in the Landfill Project Protocol. A project developer may be an independent third party or the landfill operating entity.
Qualifying destruction device	A utility flare, enclosed flare, engine, boiler, pipeline, vehicle, or fuel cell which can serve as the primary destruction device for a methane destruction project under this protocol.
Renewable Energy Certificates (RECs)	As defined by the U.S. EPA Green Power Partnership, a REC represents the property rights to the environmental, social, and other non-power qualities of renewable electricity generation. For a landfill project this is represented by the existence of a REC contract or participation of the landfill in a REC tracking system. The RECs may be sold as bundled (green power) or unbundled from the associated energy that is generated.
Reporting period	Specific time period of project operation for which the project developer has calculated and reported emission reductions and is seeking verification and issuance of credits. The reporting period must be no longer than 12 months.
Resource Conservation and Recovery Act (RCRA)	Federal legislation under which solid and hazardous waste disposal facilities are regulated.
Stationary combustion source	A stationary source of emissions from the production of electricity, heat, or steam, resulting from combustion of fuels in boilers, furnaces, turbines, kilns, and other facility equipment.

Verification	The process used to ensure that a given participant's GHG emissions or emission reductions have met the minimum quality standard and complied with the Reserve's procedures and protocols for calculating and reporting GHG emissions and emission reductions.
Verification body	An ISO-accredited and Reserve-approved firm that is able to render a verification opinion and provide verification services for operators subject to reporting under this protocol.
Verification cycle	The Reserve requires verification of landfill projects annually, but does not require verifications to be completed on specific dates. Project developers select the reporting period to be verified. Thus, each project has a unique verification cycle that begins the first time a project is verified, occurs at least annually, and ends once the crediting period expires or the project is no longer eligible, whichever happens first.
Waste in place	The cumulative amount of solid waste, measured in metric tons, that has been permanently placed into the landfill.

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Appendix A Development of the Performance Standard Threshold

The initial performance standard for the Landfill Project Protocol Version 1.0 was adopted in 2007. This analysis used as its primary data source the database of nearly 2,400 landfills in the United States developed and maintained by the U.S. EPA's Landfill Methane Outreach Program (LMOP).[32] This database does not represent all U.S. landfills, but rather a subset of all landfills that have been identified as having current LFGE projects or where potential opportunities exist for such projects. This database is updated on an ongoing basis by LMOP staff. Landfill gas projects take time to move from conception to operation (often two years or more) so the database does not see rapid, significant changes. However, it has been over four years since the Reserve first developed the Landfill Project Protocol using this database, and there have been many updates in the interim. These updates merit a new evaluation of data supporting the performance standard for this protocol.

The purpose of a performance standard analysis is to identify criteria or conditions that effectively distinguish landfill gas collection and destruction projects that are likely to be additional from those that are likely to be non-additional. The original analysis conducted in 2007 concluded that any new installation of a landfill gas collection system and/or qualifying destruction device where gas had not previously been collected and destroyed (or was destroyed using a non-qualifying destruction device) could be considered additional. Since the 2007 analysis, there has been a significant increase in the number and percentage of landfills employing gas collection and destruction systems. The purpose of this updated analysis is to identify whether new criteria are necessary to continue to ensure that only additional landfill gas destruction projects are eligible to register with the Reserve, and if so, what those criteria should be.

The focus of the original analysis, as well as this update, is on those landfills not currently subject to NSPS/EG, since these regulated landfills are generally required to collect and control landfill gas emissions.

A.1 2007 Performance Standard Analysis

Table A.1 and Table A.2 provide the summary conclusions of the Reserve's 2007 performance standard analysis, using the LMOP database available at that time. The original analysis excluded all landfills that were closed prior to 2001, since their methane production was assumed to have already dropped off significantly and they would therefore be poor candidates for landfill gas projects.

Because this database did not include information on state and local regulations, ordinances or permitting requirements that may affect landfill operations, it was necessary to make assumptions regarding additional regulatory influence on landfill operations. To estimate an upper bound for market penetration, it was assumed that all non-NSPS/EG landfills with gas collection and control systems (GCCS) were *not* required to collect and control gas (see Table

[32] LMOP is a voluntary partnership program that was created to reduce methane emissions from landfills by encouraging the use of landfill gas for energy. LMOP tracks whether or not specific landfills are required to reduce landfill gas emissions under the New Source Performance Standards and Emission Guidelines for Municipal Solid Waste Landfills (NSPS/EG), promulgated March 1996. Because LMOP is not a regulatory program, it cannot make an official EPA designation regarding any landfill's NSPS/EG status. Information relating to NSPS/EG was obtained by voluntary submittal and is subject to change over time. Therefore, LMOP cannot guarantee the validity of this information.

A.2). Under this assumption, 261 out of the 1,169 landfills had implemented voluntary landfill gas projects, equating to a market penetration of 22.3%. To construct a lower bound, it was assumed that all 166 non NSPS/EG landfills with flares were required by state and local regulations, ordinances or permitting requirements to have flares installed (see Table A.2). This assumption was based on the observation that there is generally no incentive, financial or otherwise, for a landfill to install a flare absent requirements imposed by regulations, ordinances or permitting requirements. Therefore, it is likely that many non-NSPS/EG landfills with flares are required by state or local regulation, ordinances or permitting requirements to combust landfill gas. By assuming all 166 non-NSPS/EG landfills with flares were required to combust landfill gas, a lower bound for market penetration was estimated. Under this assumption, 95 out of 1,003 unregulated landfills had implemented voluntary landfill gas projects, resulting in a "natural" (non-mandated) market penetration of 9.5%.[33]

Table A.1. Summary of Information on U.S. Landfills (NSPS/EG and Non-NSPS/EG) (2007)

	Landfills	Percent of Landfills	Number w/ LFG Collection	Percent w/ LFG Collection
Landfills in Analysis				
NSPS/EG	697	37.35	697	100
Non-NSPS/EG	1169	62.65	261	22.33
Subtotal	1866	100	958	51.34
Landfills Excluded from Analysis	518			
Total U.S. Landfills	2384			

Table A.2. Summary of Non-NSPS/EG Landfills under Assumption that Flare-Only Landfills Are Already Regulated (2007)

	Flares Included		Flares Excluded	
Non-NSPS/EG Landfills	**Number of Landfills**	**Percentage**	**Number of Landfills**	**Percentage**
Flare-Only	166	14.2	Excluded	Excluded
Electricity	67	5.7	67	6.7
Gas Projects	28	2.4	28	2.8
Subtotal	261	22.3	95	9.5
No LFG collection	908	77.7	908	90.5
Total	1169	100.0	1003	100.0
Estimated Market Penetration of LFG Collection Projects at Unregulated Landfills		**22.3%**		**9.5%**

[33] It is possible that some of the 95 projects in this category were required by state or local regulations; thus, the actual natural market penetration may have been lower. **Throughout this section, however, the term "unregulated" is used to refer to landfills that are not subject to NSPS/EG and that do not have flares installed, despite the fact that some of these landfills may still be subject to state or local regulations.**

A.2 2010 Update to the Performance Standard Analysis

In late 2010, the Reserve received an updated version of the LMOP database from the U.S. EPA. Using this new version with its updated information on nearly 2,400 landfills, it was possible to reconstruct the original analysis with more current data. This new analysis is summarized in Table A.3, Table A.4, and Table A.5.

As an initial step, we reproduced the original analysis without changing any assumptions; the only difference was the more current data, with the following exceptions:

- The categories for electricity projects and gas projects have been combined into one category of "LFGE" (landfill gas-to-energy) projects
- There are a number of non-NSPS/EG landfills in the database that specify that they have a gas collection system in place, but for which there are no records of associated flares or LFGE projects. Based on communications with LMOP staff it was assumed that these landfills have flares installed.

Under these assumptions, 227 out of 954 unregulated landfills have implemented voluntary LFGE projects, resulting in a current natural market penetration rate of 23.79%.

Table A.3. Summary of Information on U.S. Landfills (NSPS/EG and Non-NSPS/EG) (2011)

	Landfills	Percent of Landfills	Number w/ LFG Collection	Percent w/ LFG Collection
Landfills in Analysis				
NSPS/EG	382	25.20	382	100.00
Non-NSPS/EG	1134	74.80	377	33.25
Subtotal	1516	100.00	759	50.07
Landfills Excluded from Analysis[34]	877			
Total U.S. Landfills	2393			

Table A.4. Summary of Non-NSPS/EG Landfills under Assumption that Flare-Only Landfills Are Already Regulated (2011)

	Flares Included		Flares Excluded	
Non-NSPS/EG Landfills	**Number of Landfills**	**Percent of Non-NSPS Landfills**	**Number of Landfills**	**Percent of Non-NSPS Landfills**
Flare-Only	180	15.87	Excluded	Excluded
LFGE	227	20.02	227	23.79
Subtotal	407	35.89	227	23.79
No LFG Collection	727	64.11	727	76.21
Total	1134	100.00	954	100.00
Estimated Market Penetration of Gas Destruction Projects into Unregulated Landfills		**35.89%**		**23.79%**

The 23.79% natural market penetration represents a significant increase from the results of the 2007 analysis (9.5%; see Table A.2). However, it is possible that the growth in the domestic

[34] Excluded landfills are those which had closed prior to 2001.

carbon market has contributed appreciably to this increase in market penetration. By comparing the landfills included in the LMOP database with the lists of landfill projects in publicly available carbon offset project registries[35,36,37], it is possible to identify those projects that appear to have been incentivized by the GHG offset market. Assuming that all registered GHG offset projects are additional and may therefore be excluded from the analysis, the result is that 158 of 867 unregulated landfills have implemented voluntary landfill gas projects in the absence of carbon market incentives. This equates to a natural market penetration rate of 18.22% (see Table A.5).

Table A.5. Summary of Non-NSPS/EG Landfills under Assumption that Flare-Only Landfills are Already Regulated, Excluding Landfills that are Enrolled in GHG Offset Programs (2011)

	Flares Included		Flares Excluded	
Non-NSPS/EG Landfills	**Number of Landfills – Offsets Excluded**	**Percent of Non-NSPS/EG Landfills – Offsets Excluded**	**Number of Landfills – Offsets Excluded**	**Percent of Non-NSPS/EG Landfills – Offsets Excluded**
Flare-Only	146	14.41	Excluded	Excluded
LFGE Projects	158	15.60	158	18.22
Subtotal	304	30.01	158	18.22
No LFG Collection	709	69.99	709	81.78
Total	1013	100.00	867	100.00
Estimated Market Penetration of Gas Destruction Projects into Unregulated Landfills		**30.01%**		**18.22%**

The 2007 analysis excluded all landfills closed prior to 2001, based on the assumption that their gas production would now have declined too much to be considered for a gas destruction project. However, landfills are only included in the LMOP database if there is some reason to believe they have potential for a LFGE project. For conservativeness, the updated analysis presented here includes landfills closed prior to 2001, unlike the 2007 analysis. Using this expanded dataset, the following categories of landfills were excluded from further analysis:

a) Landfills that are regulated under NSPS/EG;
b) Landfills with flare-only projects; and
c) Landfills that are receiving GHG offsets.

1,507 landfills remained in the LMOP database after these exclusions. Of these landfills, 251 have installed LFGE projects. This equates to a natural market penetration rate of 16.66% (see Table A.6).

[35] Climate Action Reserve list of projects: https://thereserve1.apx.com/myModule/rpt/myrpt.asp?r=111
[36] American Carbon Registry list of projects: http://www.americancarbonregistry.org/carbon-registry/projects
[37] Chicago Climate Exchange list of projects: https://registry.chicagoclimatex.com/public/projectsReport.jsp

Table A.6. Summary of Non-NSPS/EG Landfills, Excluding Flare-Only and GHG Offset Projects

Non-NSPS/EG Landfills	Number of Landfills	Percent
LFGE Projects	251	16.66
No LFG Collection	1256	83.34
Total	1507	100.00
Estimated Market Penetration of LFGE Projects at Unregulated Landfills		**16.66%**

In other words, close to 17% of unregulated landfills have made the decision to voluntarily install and operate a LFGE system without pursuing the additional revenue from GHG offsets. This suggests that many LFGE projects are viable based solely on revenue from energy sales, and thus should not be considered additional as a GHG offset project. In fact, further analysis of the LMOP database (including landfills that closed prior to 2001) shows that 76% of LFGE projects at non-NSPS/EG landfills are not receiving revenues from GHG offsets (251 projects out of a total of 327). This supports the conclusion that many projects utilizing energy from landfill gas destruction do not require GHG offset revenues to be viable, and thus the Reserve should update its eligibility requirements to ensure the additionality of such projects. The Reserve examined two options for further restricting eligibility for LFGE projects:

1. Excluding projects that sell green power or renewable energy certificates (RECs).
2. Excluding projects above a certain size threshold.

A.3 New Performance Standard Option #1: RECs Exclusion for LFGE Projects

Although a majority of LFGE projects at non-NSPS/EG landfills do not receive revenue from GHG offsets, this does not necessarily mean that *all* such projects are viable based only on energy sales. In many areas of the country, LFGE projects are eligible to receive additional revenue in the form of green power contracts or the sale of renewable energy certificates (RECs). The market for RECs has grown and matured such that in many cases the incentive provided by RECs rivals that provided by GHG offsets. One possibility is that the LFGE projects that are not generating GHG offsets are instead obtaining additional revenue through REC sales.

To examine this possibility, the Reserve used data from the regional REC tracking registries to identify LFGE projects that currently sell RECs.[38,39] As indicated above, according to the latest LMOP data there are 251 unregulated landfills with LFGE projects that are not receiving GHG offsets (and therefore appear to be non-additional). According to the REC registry data, 61 of these projects are selling RECs. One option for an additionality threshold, therefore, is to exclude LFGE projects that sell RECs. Going strictly by the numbers presented here, this would reduce the potential number of non-additional projects that could be (incorrectly) considered additional by 24% (61 / 251).

[38] The list of projects generating RECs was generated from the publicly available registries of REC tracking systems around the U.S.: PJM, WREGIS, ERCOT, NC-RETS, NARR, M-RETS, MIRECS, and NEPOOLGIS.
[39] LFGE projects may also receive additional revenue in the form of contracts for "green" power sold to utilities or other buyers. For this analysis, data on REC sales were used a s proxy for all green power sales.

One risk, however, is that by excluding projects that generate RECs we might also exclude some truly additional projects, i.e. those that require both GHG offset and REC revenues to be viable. Of the 327 unregulated landfills that have LFGE projects installed, 28% are selling RECs, while 24% are selling GHG offsets. The majority of the projects in these categories do not overlap (i.e. most do not sell both RECs and GHG offsets). Of those projects selling RECs, 66.3% do not sell GHG offsets in addition to RECs. Similarly, almost 60% of the projects that are selling GHG offsets do not also sell RECs. (See Table A.7). The high percentages of projects that are only receiving one stream of additional revenue, RECs or GHG offsets, suggest that most projects do not need both streams of environmental incentives in order to be financially feasible. Thus, excluding projects that currently sell RECs would not seem to result in a large number of incorrect rejections, i.e. excluding projects that would be truly additional. However, it is possible these results could differ markedly depending on the region of the country and the market into which RECs or green power are being sold.

Another concern is that prohibiting offset projects from selling RECs might not be an effective screen, since projects could still opt to sell either RECs or GHG offsets. Projects that are currently selling RECs (or would otherwise have sold RECs) could decide to sell GHG offsets instead, e.g. if they would obtain more revenue by doing so. The prohibition may therefore be ineffective at directly screening out these non-additional projects. However, the market for RECs could be expected to at least partially counteract this effect. Specifically, other renewable energy projects (including other LFGE projects) could be expected to make up for the reduced supply of RECs, leading to overall net (additional) reductions.

Based on the LMOP dataset, excluding the 61 projects that are receiving RECs, the “natural” market penetration of LFGE projects at unregulated landfills drops from 16.66% to 13.14% (Table A.8).

Table A.7. Rate of Participation in Environmental Incentives Programs for Non-NSPS/EG LFGE Projects

	Number of Landfills	Percent of Unregulated LFGE Projects
Total Unregulated LFGE Projects	327	100%
No Environmental Incentives	190	58%
RECs Total	92	28%
RECs Only (No GHG Offsets)	61	
GHG Offsets Total	76	23%
GHG Offsets Only (No RECs)	45	

Table A.8. Summary of Non-NSPS/EG Landfills under Assumption that Flare-Only Landfills are Already Regulated, Excluding Landfills that are Enrolled in a GHG Offset Program and Excluding Landfills that are Receiving RECs (2011)

Non-NSPS/EG Landfills)	Number of Landfills – Offsets/RECs Excluded	Percent of Unregulated Landfills – Offsets/RECs Excluded
LFGE	190	13.14
No LFG Collection	1256	86.86
Total	1446	100.00
Estimated Market Penetration of Gas Destruction Projects into Unregulated Landfills		**13.14%**

A.4 New Performance Standard Option #2: Size Threshold for LFGE Projects

Although imposing a prohibition on selling RECs could in principle exclude a significant segment of non-additional projects from eligibility, it would still leave a sizable number as eligible. More than 13% of unregulated landfills host LFGE projects that receive no environmental incentive payments and would still be incorrectly classified as additional. Because of concerns that a REC exclusion may have limited effectiveness (and could have unintended consequences in some markets), the Reserve sought to identify other characteristics or conditions that could further distinguish between additional and non-additional projects.

In the absence of any incentives provided by the GHG offset or REC markets, the feasibility of installing a LFGE project at an unregulated landfill depends largely on the amount of methane produced at the landfill. Landfills that produce more methane are more likely to be good candidates for such projects. The amount of methane produced at a landfill can depend on a number of factors, including amount of waste in place (WIP), waste composition, age, and annual precipitation. WIP has been shown to have a large impact on methane production at the landfill, and is commonly used as an indicator for gas production. For example, the NSPS threshold that triggers more detailed regulatory testing is a design capacity for 2.5 million megagrams of WIP. Annual precipitation can also have a large impact on the gas production at a particular landfill. For example, the First Order Decay Model which is used to predict landfill gas production uses a decay rate (*k*-value) that varies based on precipitation.

Having identified two key factors in methane production potential, the next step in the Reserve's analysis was to examine the market penetration of voluntary LFGE projects at unregulated landfills as a function of the size of the landfill (measured as WIP at the time the project was installed) and annual precipitation. The LMOP database includes entries for the WIP (in tons), the year that the WIP figure was reported, and the year that a LFGE project (if any) was installed. To control for temporal disparity, projects were excluded from the analysis if the year that the WIP figure was reported diverged by more than three years from the year that the LFGE project was installed. In addition, any landfills selling GHG offset credits were excluded from the analysis. After applying these screens, a total of 411 landfills were included in the analysis.

Next, each landfill in the analysis was assigned to a precipitation zone, either "arid" or "non-arid," depending on the annual precipitation in the landfill's county. County precipitation was identified using the United States Geological Survey (USGS) map layer of Hydrologic Regions, which was aggregated into regions of less than 25 inches and regions of 25 inches or greater annual precipitation.[40] See Figure A.1 for the location of arid and non-arid precipitation zones by U.S. county.

Finally, landfills in both the arid and non-arid categories were sorted according to size (WIP). Once sorted, it was possible to determine for any given size threshold:

1. The number (and percentage) of unregulated landfills with LFGE projects whose size falls below the threshold. This is the number of LFGE projects that would incorrectly be considered additional if the threshold were applied (i.e. eligibility limited to only those landfills below the threshold).

[40] The threshold between arid and non-arid landfills of 25 inches of precipitation is based on the U.S. EPA AP 42, Fifth Edition, Volume I, Section 2.4: Municipal Solid Waste Landfills. http://www.epa.gov/ttn/chief/ap42/ch02/index.html

2. The number (and percentage) of unregulated landfills *without* LFGE projects whose size is above the threshold. This is the number of landfills that would be incorrectly *excluded* from eligibility if the threshold were applied.

Table A.9 shows the results of this analysis across a range of WIP thresholds for the arid precipitation zone. Table A.10 shows the results across a range of WIP thresholds for the non-arid precipitation zone.

Table A.9. Summary of Landfill Eligibility Results for a Range of WIP Thresholds (Arid Counties)

Arid Counties (<25" Annual Precipitation)					
WIP Threshold	Eligible Landfills	Landfills that Would Incorrectly be Considered Additional	% Landfills that Would Incorrectly be Considered Additional	Landfills that Would Incorrectly be Excluded from Eligibility	% Landfills that Would Incorrectly be Excluded from Eligibility
100,000	32	0	0.0%	62	66.0%
500,000	61	0	0.0%	33	35.1%
1,000,000	75	0	0.0%	19	20.2%
1,500,000	82	1	1.2%	13	13.8%
2,000,000	88	3	3.4%	9	9.6%
2,500,000	92	6	6.5%	8	8.5%
3,000,000	96	7	7.3%	5	5.3%
3,500,000	97	7	7.2%	4	4.3%
4,000,000	100	8	8.0%	2	2.1%
4,500,000	101	8	7.9%	1	1.1%
5,000,000	102	9	8.8%	1	1.1%
5,500,000	102	9	8.8%	1	1.1%
6,000,000	102	9	8.8%	1	1.1%
6,500,000	102	9	8.8%	1	1.1%
7,000,000	102	9	8.8%	1	1.1%
7,500,000	102	9	8.8%	1	1.1%
8,000,000	102	9	8.8%	1	1.1%
8,500,000	102	9	8.8%	1	1.1%
9,000,000	103	9	8.7%	0	0.0%

Table A.10. Summary of Landfill Eligibility Results for a Range of WIP Thresholds (Non-Arid Counties)

Non-Arid Counties (>25" Annual Precipitation)					
WIP Threshold	Eligible Landfills	Landfills that Would Incorrectly be Considered Additional	% Landfills that Would Incorrectly be Considered Additional	Landfills that Would Incorrectly be Excluded from Eligibility	% Landfills that Would Incorrectly be Excluded from Eligibility
100,000	29	0	0.0%	213	88.0%
300,000	56	1	1.8%	187	77.3%
600,000	97	4	4.1%	149	61.6%
900,000	139	13	9.4%	116	47.9%
1,200,000	187	18	9.6%	73	30.2%
1,500,000	213	24	11.3%	53	21.9%
1,800,000	226	27	11.9%	43	17.8%
2,100,000	248	34	13.7%	28	11.6%
2,400,000	259	38	14.7%	21	8.7%
2,700,000	268	42	15.7%	16	6.6%
3,000,000	274	46	16.8%	14	5.8%
3,300,000	280	49	17.5%	11	4.5%
3,600,000	284	51	18.0%	9	3.7%
3,900,000	294	56	19.0%	4	1.7%
4,200,000	298	57	19.1%	1	0.4%
4,500,000	299	58	19.4%	1	0.4%
4,800,000	301	60	19.9%	1	0.4%
5,100,000	302	61	20.2%	1	0.4%
5,400,000	302	61	20.2%	1	0.4%
5,700,000	304	63	20.7%	1	0.4%
6,000,000	304	63	20.7%	1	0.4%
6,300,000	304	63	20.7%	1	0.4%
6,600,000	304	63	20.7%	1	0.4%
6,900,000	304	63	20.7%	1	0.4%
7,200,000	304	63	20.7%	1	0.4%
7,500,000	305	64	21.0%	1	0.4%
7,800,000	305	64	21.0%	1	0.4%
8,100,000	305	64	21.0%	1	0.4%
8,400,000	305	64	21.0%	1	0.4%
8,700,000	305	64	21.0%	1	0.4%
9,000,000	305	64	21.0%	1	0.4%
9,300,000	306	65	21.2%	1	0.4%
9,600,000	306	65	21.2%	1	0.4%
9,900,000	306	65	21.2%	1	0.4%
10,200,000	307	65	21.2%	0	0.0%

Based on this sorting, the Reserve identified a WIP threshold for each precipitation zone that effectively screened out a majority of non-additional LFGE projects. The objective of excluding non-additional projects, however, had to be balanced against concerns about unfairly excluding landfills from eligibility where no projects currently exist. The result was to target a WIP threshold for each zone such that the percentage of unregulated landfills with LFGE projects was 5% or less (i.e. the "natural" market penetration of LFGE projects at landfills below the threshold was no more than 5%). For landfills in the arid precipitation zone, this threshold was determined to be 2.17 million metric tons (MMT). For landfills in the non-arid precipitation zone, this threshold was determined to be 0.72 MMT (Table A.11).

The percentage of incorrectly excluded landfills at these thresholds differs markedly for the arid and non-arid zones. For the arid zone, only 10% of unregulated landfills without LFGE projects are incorrectly excluded. For the non-arid zone, however, nearly 60% of unregulated landfills without LFGE projects are incorrectly excluded. Although this is a high rate of incorrect exclusions, the Reserve believes it is important to strike a balance strongly in favor of ensuring that projects that *do* pass an additionality screen are likely to be additional. In the absence of alternative characteristics or conditions that could be used to screen for additional projects, the Reserve believes it is necessary to adopt a stringent WIP threshold.

Table A.11. WIP Values for 5% Market Penetration of LFGE Projects[41]

	Arid Counties (<25" Annual Precipitation)	Non-Arid Counties (>25" Annual Precipitation)
WIP Threshold for 5% Market Penetration of LFGE Projects at Unregulated Landfills (metric tons)	2,165,000	715,000
Percentage of Landfills with No LFG Collection Excluded by this WIP Threshold	10%	58%

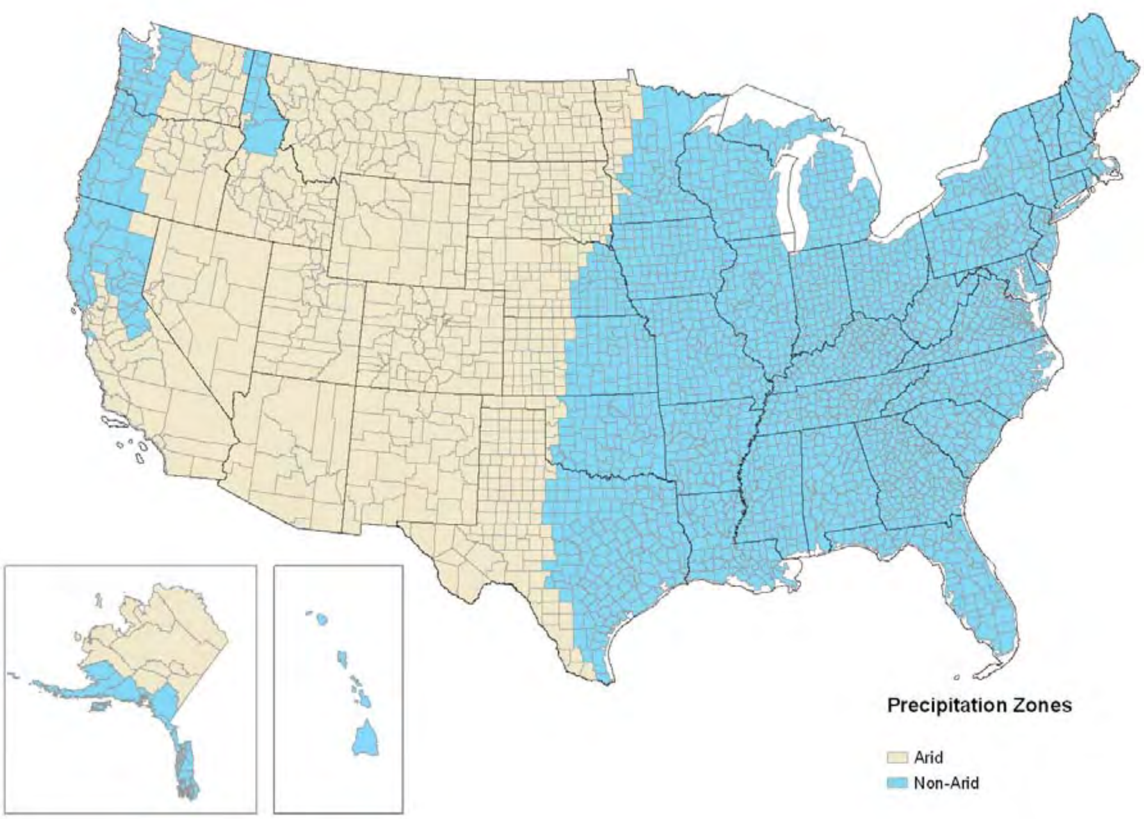

Figure A.1. Precipitation Zones of the United States, by County

Based on the USGS Hydrologic Zones of the United States (2003). Arid counties average less than 25 inches of precipitation annually, and non-arid counties average 25 inches or greater precipitation annually.

[41] As suggested in footnote 33, it is likely that some of the LFGE projects at landfills not subject to NSPS/EG and below the size thresholds presented here are in fact required by local regulations. Thus, the actual "natural" market penetration below these thresholds is likely to be below 5%, and may be significantly below 5%. The analysis conservatively assumes that none are legally required.

Appendix B Development of the NMOC Emissions Threshold

B.1 Purpose

For the specific case in which a landfill gas control system is required to treat landfill gas for NMOC in order to comply with a regulation, ordinance, or permitting condition, but destruction of the landfill gas is not the only compliance mechanism available to the landfill operator, the Reserve has developed an NMOC emissions threshold whereby the eligibility of a project can be determined. If a landfill gas control system is required to treat landfill gas for NMOC and the total mass flow of NMOC for the landfill gas control system is less than the threshold (measured in pounds NMOC per month), then the landfill gas control system is eligible as a GHG reduction project under this protocol. If a landfill gas control system is required to treat landfill gas for NMOC and the total mass flow of NMOC for the landfill gas control system is greater than the threshold, then the landfill gas control system is *not* eligible as a GHG reduction project under this protocol. The Reserve has established two separate NMOC thresholds for 1) landfills in air management districts or regions that permit the use of open flares, and 2) landfills in air management districts or regions that permit *only* enclosed flares.

The NMOC mass flow at a given landfill is one of many factors including the quantity, age and composition of the waste, and the environmental conditions at the landfill.

B.2 Data

The primary data source for the threshold analysis is a series of empirical capital cost and monthly operating cost data supplied to the Reserve from fourteen landfills with experience using carbon adsorption to treat varying levels of NMOC. In addition, the Reserve obtained quotes for the purchase, installation, and operation of both open (candlestick or utility-type) flares and enclosed flares from a number of prominent vendors and engineering firms.[42]

B.3 Summary

The analysis below reveals that an estimated NMOC[43] mass flow threshold of 1,775 lbs NMOC/month is appropriate for the performance standard in areas where open flares may be used, and a threshold of 2,575 is appropriate for the performance standard in areas where only enclosed flares may be installed. This analysis was performed based on the empirical data and estimates obtained for flare and carbon adsorption systems with capacities of 40 to 1,000 cubic feet per minute (CFM) of landfill gas and an operational life of ten years. While the upfront costs for a flare system are relatively high (approximately $200,000 for an open flare and $290,000 for an enclosed flare), the costs for installing a carbon adsorption system are significantly lower (typically below $20,000). Both systems require comparable operation and maintenance costs, but the carbon adsorption system has an additional cost associated with the replacement and disposal of activated carbon. As NMOC levels increase, additional carbon is required, and therefore costs increase as well. The overall cost of a carbon adsorption system is therefore highly dependent on the mass flow of NMOC, as the carbon must be replaced once saturated. Thus, determining the NMOC threshold is a matter of identifying the NMOC level that requires carbon costs equal to or greater than the additional cost of the flare. The analysis shows that the installation of an open flare system for NMOC control is more cost effective than carbon

[42] Due to proprietary confidentiality, the landfill operations and service providers who provided operational data and cost quotes will remain anonymous.
[43] NMOC concentration (ppmv) normalized to hexane.

adsorption if the measured landfill gas flow rate (CFM) and NMOC concentration (ppmv) result in a total mass flow of 1,775 lbs of NMOC per month or greater. For an enclosed flare, this break-even point is 2,575 lbs of NMOC per month. Above these levels, costs of carbon adsorption systems, particularly the monthly carbon replacement costs, become cost prohibitive relative to flare systems even in light of the high capital costs of flares.

B.4 Methodology

In order to carry out this analysis, the Reserve required reliable cost information for both carbon adsorption and open and enclosed flare systems. These data were obtained by soliciting quotes from the technical sales departments of well known flare vendors, and from historical data at sites utilizing carbon adsorption. Multiple quotes were obtained for each flare system type to accurately reflect the costs of open and enclosed systems scaled to 1,000 CFM. These quotes allowed the Reserve to calculate a net present value (NPV) cost of the purchase, installation, transportation, and basic instrumentation of the flare systems and purchase, installation, and carbon replacement costs of carbon systems over a ten-year operational life. This analysis applied an 8% discount rate. A summary of these costs is provided in Table B.1 and Table B.2.

The Reserve used these data and relationships to calculate the NMOC mass flow at which an open or enclosed landfill flare becomes more cost effective than a carbon adsorption system. This was done by first calculating the NPV cost to treat one pound of NMOC per month for ten years in each of the carbon systems analyzed, and then determining how many pounds of NMOC could be treated at that cost for the NPV cost of the flares. This value represents the NMOC threshold: the NMOC mass flow at which a landfill operator would be indifferent as to which technology was installed.

Total NPV costs for the enclosed and open flares were calculated as follows:

$$Cost_{Flare,j} = \frac{Capital_{Flare,j}}{(1+0.08)^t}$$

Where,

			Units
$Cost_{Flare,i}$	=	NPV of total costs (excluding O&M) of flare *j*	$
$Capital_{Flare,j}$	=	Capital cost of flare purchase, transportation, installation, and basic instrumentation, for flare *j*	$
t	=	Year in which expense was accrued	

Total NPV cost for the carbon adsorption system was calculated as follows:

$$Cost_{Carbon,i} = Capital_{Carbon} + \sum_{t=1year}^{10} \frac{(Carbon_{month,i} \times 12)}{(1+0.08)^t}$$

Where,

			Units
$Cost_{Carbon,i}$	=	NPV of total costs (excluding non-carbon related O&M) of carbon system *i*	$
$Capital_{Carbon}$	=	Capital cost purchase and installation of carbon system *i*	$
$Carbon_{month,i}$	=	Monthly cost of purchasing, transporting, and disposing of carbon at carbon system *i*	$/month
12	=	Months per year	month
0.08	=	Annual discount rate	
t	=	Year in which expense was accrued, 1 through 10	

Using the total NPV cost of each carbon adsorption system, the Reserve was able to establish the ten-year NPV cost of treating one pound of NMOC per month by dividing $Cost_{Carbon,i}$ by the NMOC mass flow associated with that system.

$$NMOCCost_{Carbon,i} = \frac{Cost_{Carbon,i}}{NMOC_{month,i}}$$

Where,

			Units
$NMOCCost_{Carbon,i}$	=	NPV of treating 1 pound of NMOC per month for 10 years, using carbon system *i*	$/lb
$NMOC_{month,i}$	=	Pounds per month of NMOC treated by carbon system *i*	lb/month

Next, by dividing the cost of the flare, the Reserve arrived at the break-even amount of carbon that could be treated for the same cost using either a flare or carbon system. This analysis was run separately for both the open and enclosed flares.

$$NMOC_{Threshold} = \frac{Cost_{flare,j}}{NMOCCost_{Carbon,i}}$$

Where,

			Units
$NMOC_{Threshold}$	=	Pounds of NMOC that can be treated for the same cost using either carbon system *i* or flare system *j*	lb/month

The resulting NMOC threshold at each carbon facility was averaged to obtain a single NMOC threshold for open flare facilities, and a separate one for enclosed flare facilities.

B.5 Results

Quotes for both open and enclosed flares obtained by the Reserve and used in this analysis are provided below in Table B.1.

Table B.1. Quotes from Vendors/Engineering Firms for the Cost of Flare, Transportation, Installation, and Basic Instrumentation

Open Flare Quote	Bid
1	$116,500
2	$150,000
3	$275,000
4	$137,000
5	$157,500
6	$265,000
7	$310,000
8	$190,000
Average	**$200,125**

Enclosed Flare Quote	Bid
1	$185,000
2	$335,000
3	$215,000
4	$320,000
5	$195,000
6	$415,000
7	$350,000
Average	**$287,857**

The analysis included in this table incorporates installation costs for open flares of $200,000 and for enclosed flares of $290,000. These values represent an average cost of purchase, transportation, installation, and basic instrumentation for open and enclosed flares. Costs for well fields and blower systems are expected to be comparable for both carbon systems and flare systems and are therefore not included in the analysis.

A summary of the cost data for carbon systems used in this analysis is provided in Table B.2. This table also provides the results of the analysis comparing each of the site’s costs to those necessary to treat the NMOC using an open or enclosed flare.

Table B.2. Summary of Install and Monthly Carbon Costs for Carbon Adsorption Systems at 14 Landfills

Site	Capital Cost ($)	Monthly Costs ($)	Total 10 yr NPV ($)	NMOC Rate (lb/mo)	10 yr NPV NMOC ($/lb/mo)	NMOC Threshold (Open Flare)	NMOC Threshold (Enclosed Flare)
1	$7,200	$710	$64,343	1,376	$47	4,277	6,203
2	$2,400	$1,281	$105,547	1,649	$64	3,124	4,530
3	$9,112	$1,702	$146,155	465	$315	635	922
4	$12,000	$770	$74,001	953	$78	2,574	3,734
5	$15,120	$3,915	$330,360	494	$669	299	434
6	$2,400	$1,300	$107,077	362	$296	676	981
7	$0	$1,386	$111,602	125	$893	224	325
8	$1,200	$265	$22,538	65	$347	575	835
9	$21,000	$680	$75,754	199	$381	524	760
10	$6,550	$377	$36,880	1,229	$30	6,665	9,665
11	$12,000	$2,735	$232,198	3,736	$62	3,217	4,666
12	$800	$1,686	$136,594	729	$187	1,067	1,548
13	$2,400	$2,074	$169,414	87	$1,937	103	150
14	$2,400	$1,975	$161,455	716	$226	886	1,286
Average						**1,775**	**2,574**

As demonstrated above, the Reserve established an NMOC threshold of 1,775 lbs of NMOC per month at sites where open flares may be permitted, and 2,575 lbs of NMOC per month at sites where only enclosed flares may be installed.

Landfills for which the NMOC threshold applies, and which fall below the applicable threshold, are required to test for and calculate NMOC mass flow rates on an annual basis. If a test indicates a value above the applicable threshold, the landfill must commence quarterly NMOC analyses. Upon registering two consecutive quarterly NMOC tests above the applicable threshold, the landfill will be deemed to fail the NMOC threshold test and will be ineligible per the performance standard.

Appendix C Emission Factor Tables

Table C.1. CO_2 Emission Factors for Fossil Fuel Use

Fuel Type	Heat Content	Carbon Content (Per Unit Energy)	Fraction Oxidized	CO_2 Emission Factor (Per Unit Energy)	CO_2 Emission Factor (Per Unit Mass or Volume)
Coal and Coke	**MMBtu / Short ton**	**kg C / MMBtu**		**kg CO_2 / MMBtu**	**kg CO_2 / Short ton**
Anthracite Coal	25.09	28.26	1.00	103.62	2,599.83
Bituminous Coal	24.93	25.49	1.00	93.46	2,330.04
Sub-bituminous Coal	17.25	26.48	1.00	97.09	1,674.86
Lignite	14.21	26.30	1.00	96.43	1,370.32
Unspecified (Residential/ Commercial)	22.05	26.00	1.00	95.33	2,102.29
Unspecified (Industrial Coking)	26.27	25.56	1.00	93.72	2,462.12
Unspecified (Other Industrial)	22.05	25.63	1.00	93.98	2,072.19
Unspecified (Electric Utility)	19.95	25.76	1.00	94.45	1,884.53
Coke	24.80	31.00	1.00	113.67	2,818.93
Natural Gas (By Heat Content)	**Btu / Standard cubic foot**	**kg C / MMBtu**		**kg CO_2 / MMBtu**	**kg CO_2 / Standard cub. ft.**
975 to 1,000 Btu / Std cubic foot	975 – 1,000	14.73	1.00	54.01	Varies
1,000 to 1,025 Btu / Std cubic foot	1,000 – 1,025	14.43	1.00	52.91	Varies
1,025 to 1,050 Btu / Std cubic foot	1,025 – 1,050	14.47	1.00	53.06	Varies
1,050 to 1,075 Btu / Std cubic foot	1,050 – 1,075	14.58	1.00	53.46	Varies
1,075 to 1,100 Btu / Std cubic foot	1,075 – 1,100	14.65	1.00	53.72	Varies
Greater than 1,100 Btu / Std cubic foot	> 1,100	14.92	1.00	54.71	Varies
Weighted U.S. Average	1,029	14.47	1.00	53.06	0.0546
Petroleum Products	**MMBtu / Barrel**	**kg C / MMBtu**		**kg CO_2 / MMBtu**	**kg CO_2 / gallon**
Asphalt & Road Oil	6.636	20.62	1.00	75.61	11.95
Aviation Gasoline	5.048	18.87	1.00	69.19	8.32
Distillate Fuel Oil (#1, 2 & 4)	5.825	19.95	1.00	73.15	10.15
Jet Fuel	5.670	19.33	1.00	70.88	9.57
Kerosene	5.670	19.72	1.00	72.31	9.76
LPG (average for fuel use)	3.849	17.23	1.00	63.16	5.79
Propane	3.824	17.20	1.00	63.07	5.74
Ethane	2.916	16.25	1.00	59.58	4.14
Isobutene	4.162	17.75	1.00	65.08	6.45
n-Butane	4.328	17.72	1.00	64.97	6.70
Lubricants	6.065	20.24	1.00	74.21	10.72
Motor Gasoline	5.218	19.33	1.00	70.88	8.81
Residual Fuel Oil (#5 & 6)	6.287	21.49	1.00	78.80	11.80
Crude Oil	5.800	20.33	1.00	74.54	10.29
Naphtha (<401 deg. F)	5.248	18.14	1.00	66.51	8.31
Natural Gasoline	4.620	18.24	1.00	66.88	7.36
Other Oil (>401 deg. F)	5.825	19.95	1.00	73.15	10.15
Pentanes Plus	4.620	18.24	1.00	66.88	7.36
Petrochemical Feedstocks	5.428	19.37	1.00	71.02	9.18
Petroleum Coke	6.024	27.85	1.00	102.12	14.65
Still Gas	6.000	17.51	1.00	64.20	9.17
Special Naphtha	5.248	19.86	1.00	72.82	9.10
Unfinished Oils	5.825	20.33	1.00	74.54	10.34
Waxes	5.537	19.81	1.00	72.64	9.58

Source: EPA Climate Leaders, Stationary Combustion Guidance (2007), Table B-2 except:
Default CO_2 emission factors (per unit energy) are calculated as: Carbon Content × Fraction Oxidized × 44/12.
Default CO_2 emission factors (per unit mass or volume) are calculated as: Heat Content x Carbon Content × Fraction Oxidized × 44/12× Conversion Factor (if applicable). Heat content factors are based on higher heating values (HHV).

Destruction Efficiencies for Combustion Devices

If available, the official source tested methane destruction efficiency shall be used in Equation 5.4 in place of the default methane destruction efficiency. Otherwise, project developers have the option to use either the default methane destruction efficiencies provided, or the site specific methane destruction efficiencies as provided by a state or local agency accredited source test service provider, for any of the destruction devices used in the project, performed on an annual basis. Device-specific source testing shall include at least three test runs, with the accepted final value being one standard deviation below the mean of the measured efficiencies.

Table C.2. Default Destruction Efficiencies for Combustion Devices

Destruction Device	Destruction Efficiency (DE)
Open Flare	0.96
Enclosed Flare	0.995
Lean-burn Internal Combustion Engine	0.936
Rich-burn Internal Combustion Engine	0.995
Boiler	0.98
Microturbine or large gas turbine	0.995
Upgrade and use of gas as CNG/LNG fuel	0.95
Upgrade and injection into natural gas transmission and distribution pipeline	0.98*
Offsite use of gas under direct-use agreement	Per corresponding destruction device factor (not pipeline)

Source: The default destruction efficiencies for enclosed flares and electricity generation devices are based on a preliminary set of actual source test data provided by the Bay Area Air Quality Management District. The default destruction efficiency values are the lesser of the twenty fifth percentile of the data provided or 0.995. These default destruction efficiencies may be updated as more source test data is made available to the Reserve.

***** The Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories gives a standard value for the fraction of carbon oxidized for gas destroyed of 99.5% (Reference Manual, Table 1.6, page 1.29). It also gives a value for emissions from processing, transmission and distribution of gas which would be a very conservative estimate for losses in the pipeline and for leakage at the end user (Reference Manual, Table 1.58, page 1.121). These emissions are given as 118,000kgCH_4/PJ on the basis of gas consumption, which is 0.6%. Leakage in the residential and commercial sectors is stated to be 0 to 87,000kgCH_4/PJ, which equates to 0.4%, and in industrial plants and power station the losses are 0 to 175,000kg/CH_4/PJ, which is 0.8%. These leakage estimates are compounded and multiplied. The methane destruction efficiency for landfill gas injected into the natural gas transmission and distribution system can now be calculated as the product of these three efficiency factors, giving a total efficiency of (99.5% * 99.4% * 99.6%) 98.5% for residential and commercial sector users, and (99.5% * 99.4% * 99.2%) 98.1% for industrial plants and power stations. [44]

[44] GE AES Greenhouse Gas Services, Landfill Gas Methodology, Version 1.0 (July 2007).

Appendix D Baseline Monitoring and Calculation of LFG_{B1}, LFG_{B2}, and B_{CH4}

This appendix shall be used to calculate LFG_{B2} and $B_{CH4,NQ}$ for use in Equation 5.7. Much of the discussion here is concerned with accommodating the added complexity of monitoring passive flares and other non-qualifying devices. However, the methodology described is also applicable for measuring and documenting LFG_{B1} and $B_{CH4,closed}$ for calculating $Closed_{discount}$ in Equation 5.6.

D.1 Baseline Monitoring

Passive flares and other non-qualifying destruction devices are often installed at landfills for purposes other than methane destruction, and therefore are not amenable to simple monitoring. For example, flares installed for odor control may be used intermittently and without any instrumentation tracking gas flow and methane concentration. This makes assessing baseline methane destruction from passive flares extremely difficult to quantify. Quantification is further exacerbated by the fact that passive flares are not necessarily designed to accommodate metering equipment; for example, in many cases passive flares do not have sufficient straight pipe length to control for turbulence. These limitations, combined with the low flow rates generally seen at passive flares greatly limit the number and type of metering equipment that can be used. Monitoring destruction of landfill gas from baseline landfill gas wells at closed landfill flares will face fewer obstacles.

The Reserve recognizes that the constraints on monitoring landfill gas from passive flares are unique to each landfill. We have attempted to make this methodology as flexible as possible to make it widely applicable. Any deviations from this methodology will require a formal request for variance.

D.2 Monitoring

Non-qualifying destruction devices (e.g. passive flares) and qualifying flares at closed landfills must be monitored for a period of at least three months. This period must occur prior to the project start date to ensure that the measured gas flow is not decreased by the addition of project wells or pressure changes that result from the project activity. Methane destruction from the chosen period must be extrapolated to one year based on the 90% upper confidence limit of the methane destruction identified in this period. Therefore, monitoring for more than three months, or with greater than weekly frequency, may lessen statistical uncertainty and reduce the required $NQ_{discount}$ or $Closed_{discount}$.

Gas flow must be measured weekly at a minimum, and must be normalized to maximum flow capacity (scfm). If gas flow falls below the measurable range for the chosen metering device, the minimum flow value of the chosen metering device must be applied to that time interval. Methane concentration must also be measured at least weekly.

One measurement should be entered on each day for which readings were taken. If continuous measurements were taken, these should be averaged. If a single measurement was taken, then this value should be used. Therefore, if a daily monitoring plan is chosen for the three month period, a total of 90 data points will be available (one per day). However, if weekly measurements are taken, then only 13 data points will be available for the analysis (one per week). Alternatively, irregular measurement intervals (for example, if someone is on-site three consecutive days) or bi-weekly measurements can be used as well, allowing for anywhere between 13 and 90 data points for any 90 day period. However, no more than one data point per calendar day may be applied and all collected data must be used.

All metering equipment used in baseline monitoring is subject to the same maintenance, calibration, and QA/QC requirements outlined previously for project metering equipment. In the case where a project does not meet the baseline monitoring maintenance, calibration, and QA/QC requirements of this protocol version, it shall be acceptable for that project to have its baseline monitoring, maintenance, calibration, and QA/QC verified against the requirements of a previous version of this protocol, so long as it is the version that was in force at the beginning date of the project's baseline monitoring period.

D.3 Passive Flare Configuration

As the configuration of passive flares will be unique to each landfill, it is not possible to dictate a single monitoring methodology. Rather, the following options have been devised as acceptable configurations.

1. Each passive flare will be monitored individually for both flow and methane concentration according to the schedule outlined in Section D.2.
2. Wells from two or more passive flares may be connected to a single flare with a single set of meters for both flow and methane concentration. Additional engineering may be required to ensure that the altered pressure characteristics of the system do not decrease total gas flow. The flow characteristics of this system will require substantiation from engineering documents and calculations and will be assessed by the verification body.
3. Wells from two or more passive flares may be connected with the active collection system and monitored separately from the new project wells while under vacuum from the blower.

D.4 Calculation

Please use Equation D.1 to calculate the $Closed_{discount}$ and Equation D.2 to calculate the $NQ_{discount}$.

Equation D.1. Calculation of Baseline Discount for Flares at a Closed Landfill

$$Closed_{discount} = 525{,}600 \times CH_{4\min}$$

$$LFG_{B1} = 525{,}600 \times 90\%UCL(LFG_{scfm})$$

Where,

			Units
LFG_{B1}	=	Landfill gas from the baseline landfill gas wells that would have been destroyed by the qualifying destruction system during the reporting period	scf LFG
$90\%UCL(LFG_{scfm})$	=	90% upper confidence limit of the average flow rate in the metered period (must be >3 months)	scfm LFG
525,600	=	Minutes in one year	min/yr

$$B_{CH_4,closed} = 90\%UCL\left(B_{CH_4,closed,t}\right)$$

Where,

			Units
$B_{CH4,closed,t}$	=	Methane concentration for baseline calculations	scf CH_4/ scf LFG
$90\%UCL(B_{CH4,closed,t})$	=	90% upper confidence limit of the average methane concentration in the metered period (must be >3 months)	scf CH_4/ scf LFG

$$90\%UCL = mean + t_{value} \times \left(\frac{SD}{\sqrt{n}}\right)$$

Where,

			Units
mean	=	Sample mean (of $B_{CH4,closed,t}$ or LFG_{scfm})	scf or %
t_{value}	=	The 90% t-value coefficient for data set with degrees of freedom *df* (use Excel feature: =TINV(0.1,df)	
SD	=	Standard deviation of the sample (of $B_{CH4,closed,t}$ or LFG_{scfm})	scf or %
n	=	Sample size	
df	=	Degrees of freedom (= n-1)	

Equation D.2. Calculation of Baseline Discount for a Non-Qualifying Device

$$NQ_{Discount} = 525{,}600 \times CH_{4\min}$$

$$LFG_{B2} = 525{,}600 \times 90\%UCL(LFG_{scfm})$$

Where, Units

LFG_{B2}	=	Landfill gas that would have been destroyed by the original, non-qualifying destruction system during the reporting period	scf LFG
$90\%UCL(LFG_{scfm})$	=	90% upper confidence limit of the average flow rate in the metered period (must be >3 months)	scfm LFG
525,600	=	Minutes in one year	min/yr

$$B_{CH_4,NQ} = 90\%UCL\left(B_{CH_4,NQ,t}\right)$$

Where, Units

$B_{CH4,NQ,t}$	=	Methane concentration for baseline calculations	scf CH_4/ scf LFG
$90\%UCL(B_{CH4,NQ,t})$	=	90% upper confidence limit of the average methane concentration in the metered period (must be >3 months)	scf CH_4/ scf LFG

$$90\%UCL = mean + t_{value} \times \left(\frac{SD}{\sqrt{n}}\right)$$

Where, Units

mean	=	Sample mean (of $B_{CH4,NQ,t}$ or LFG_{scfm})	scf or %
t_{value}	=	The 90% t-value coefficient for data set with degrees of freedom *df* (use Excel feature: =TINV(0.1,df)	
SD	=	Standard deviation of the sample (of $B_{CH4,NQ,t}$ or LFG_{scfm})	scf or %
n	=	Sample size	
df	=	Degrees of freedom (= n-1)	

D.5 Example

The following example (Table D.1) demonstrates the necessary calculation for calculation of $Closed_{discount}$ or $NQ_{discount}$. The calculations outlined above in Section D.4 are represented by the first three columns of data. The final conversions to tCO_2e/yr are done using Equation 5.5.

Note that although the measurements had average values yielding a deduction of 5,961 tCO_2e/yr, due to the limited data and variability of the measurements, the appropriate deduction is 7,830 tCO_2e/yr. If, instead of weekly data there was daily data over this three month period that yielded the exact same mean and standard deviation, the additional data alone would have lowered the deduction to only 6,807 tCO_2/yr. Alternately, if the data had been more consistent and showed a standard deviation for the flow data of only 6 with the same mean, then the deduction with 14 samples would have been only 6,689 tCO_2/yr. Therefore, the added uncertainty deduction of this method is directly related to the level of variability in the data and the number of samples.

Table D.1. Example Dataset and Calculation of $Closed_{discount}$ or $NQ_{discount}$

	Calculating According to Equations D.1 and D.2				**Calculated According to Equation 5.5**	
	CH_4 (%)	**Flow (scfm)**	**Flow CH_4 (scfm)**	**CH_4/year (scf/yr)**	**CH_4/year (t/yr)**	**tCO_2e/year**
6/1/2008	56.7	48	27	14,304,703	274	5,760
6/8/2008	55.3	75	41	21,799,260	418	8,778
6/15/2008	58.1	21	12	6,412,846	123	2,582
6/22/2008	54.0	90	49	25,544,160	490	10,286
6/29/2008	55.6	47	26	13,734,979	263	5,531
7/6/2008	56.3	23	13	6,805,994	131	2,741
7/13/2008	57.2	70	40	21,045,024	404	8,475
7/20/2008	58.0	15	9	4,572,720	88	1,841
7/27/2008	52.3	89	47	24,465,103	469	9,852
8/3/2008	55.7	42	23	12,295,886	236	4,951
8/10/2008	54.8	51	28	14,689,469	282	5,915
8/17/2008	62.1	19	12	6,201,554	119	2,497
8/24/2008	59.3	66	39	20,570,933	394	8,284
8/31/2008	57.6	70	40	21,192,192	406	8,534
Mean	**56.6**	**51.86**	**28**	**14,803,281**	**284**	**5,961**
SD	0.02	25.70				
n	14	14				
df	13	13				
90% t-value	1.77	1.77				
UCL at 90%	**57.8**	**64.02**	**37**	**19,443,275**	**373**	**7,830**

Appendix E Data Substitution Guidelines

This appendix provides guidance on calculating emission reductions when data integrity has been compromised due to missing data points. No data substitution is permissible for equipment such as thermocouples, which monitor the proper functioning of destruction devices. Rather, the methodologies presented below are to be used only for the methane concentration and flow metering parameters.

The Reserve expects that projects will have continuous, uninterrupted data for the entire verification period. However, the Reserve recognizes that unexpected events or occurrences may result in brief data gaps.

The following data substitution methodology may be used only for flow and methane concentration data gaps that are discrete, limited, non-chronic, and due to unforeseen circumstances. Data substitution can only be applied to methane concentration *or* flow readings, but not both simultaneously. If data is missing for both parameters, no reductions can be credited.

Further, substitution may only occur when two other monitored parameters corroborate proper functioning of the destruction device and system operation within normal ranges. These two parameters must be demonstrated as follows:

1. Proper functioning can be evidenced by thermocouple readings for flares, energy output engines, etc.
2. For methane concentration substitution, flow rates during the data gap must be consistent with normal operation.
3. For flow substitution, methane concentration rates during the data gap must be consistent with normal operations.

If corroborating parameters fail to demonstrate any of these requirements, no substitution may be employed. If the requirements above can be met, the following substitution methodology maybe applied:

Duration of Missing Data	Substitution Methodology
Less than six hours	Use the average of the four hours immediately before and following the outage
Six to 24 hours	Use the 90% lower or upper confidence limit of the 24 hours prior to and after the outage, whichever results in greater conservativeness
One to seven days	Use the 95% lower or upper confidence limit of the 72 hours prior to and after the outage, whichever results in greater conservativeness
Greater than one week	No data may be substituted and no credits may be generated

The lower confidence limit should be used for both methane concentration and flow readings for landfill projects, as this will provide the greatest conservativeness.

For weekly measured methane concentration, the lower of the measurement before and the measurement after must be used. This substitution may only be used to substitute data for one consecutive missing weekly measurement.

U.S. Livestock Project Protocol V4.0

Protocol Summary

Project Definition

The installation of a biogas control system (BCS) that captures and destroys methane (CH_4) gas from manure treatment and/or storage facilities on livestock operations.

The protocol accepts a wide range of technologies, including:

- Centralized digesters
- Co-digestion of organic waste (greenhouse gas [GHG] benefits not quantified for non-manure waste streams)
- Methane destruction onsite (enclosed flare, open flare, electricity generation, thermal energy production)
- Methane destruction offsite (direct use via pipeline)
- Methane destroyed as fuel for vehicles (onsite or offsite)
- Biogas destruction in fuel cells

Project Eligibility Requirements

Location: Project must be within the U.S., its territories, or on U.S. tribal lands.

Start Date: Project developer can choose start date within six months from date at which manure is first loaded into the BCS, allowing for an initial start-up period. Project must be submitted within six months of becoming operational, i.e. when BCS begins producing and destroying methane after start-up period.

Performance Standard: Installation of one of the technologies accepted in the protocol.

Legal Requirement Test: During the first crediting period, project developer must sign the Attestation of Voluntary Implementation once at the project's first verification. During the second crediting period, project developer must sign the Attestation of Voluntary Implementation each reporting period, and no more CRTs will be generated from the date a project becomes legally required.

Regulatory Compliance: Project must be in compliance with all federal, state, and local laws or regulations. Project developer must sign the Attestation of Regulatory Compliance for each verification period.

Baseline:

- Baseline represents "business as usual" or what would have occurred without the BCS installation; assumes continuation of current practices
- Calculated monthly for each year of the project
- Greenfield projects (implemented at sites less than two years old with no previous manure management infrastructure) must use standardized baseline management assumptions (see Table B.10 in protocol)

Crediting Period: Project is eligible to receive credits for 10 years from start date. Project may apply for a second 10-year crediting period.

Reporting and Verification Schedule: Minimum of annual reporting with three verification options:

- Option 1: 12-month maximum verification period (with option for sub-annual verification)
- Option 2: 12-month verification period with desktop verification as appropriate
- Option 3: 24-month maximum verification period

Project Exclusions

- Any GHG reductions from other activities and changes in operations not associated with installation of a BCS
- Any greenfield sites in geographic locations where anaerobic lagoons are not common practice
- N_2O sources within the GHG Assessment Boundary
- Biogenic CO_2 associated with the BCS
- Displacement of fossil fuel consumption associated with production of electric power for the grid or injection of gas to a pipeline

Important Note: This is only a summary of the protocol. Please read the full protocol for a complete description of project requirements.

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U.S. Livestock Project Protocol
Version 4.0
ERRATA AND CLARIFICATIONS

The Climate Action Reserve (Reserve) published its U.S. Livestock Project Protocol Version 4.0 (LSPP V4.0) in January 2013. While the Reserve intends for the LSPP V4.0 to be a complete, transparent document, it recognizes that correction of errors and clarifications will be necessary as the protocol is implemented and issues are identified. This document is an official record of all errata and clarifications applicable to the LSPP V4.0.[1]

Per the Reserve's Program Manual, both errata and clarifications are considered effective on the date they are first posted on the Reserve website. The effective date of each erratum or clarification is clearly designated below. All listed and registered livestock projects must incorporate and adhere to these errata and clarifications when they undergo verification. The Reserve will incorporate both errata and clarifications into future versions of the protocol.

All project developers and verification bodies must refer to this document to ensure that the most current guidance is adhered to in project design and verification. Verification bodies shall refer to this document immediately prior to uploading any Verification Statement to assure all issues are properly addressed and incorporated into verification activities.

If you have any questions about the updates or clarifications in this document, please contact Policy at policy@climateactionreserve.org or (213) 891-1444 x3.

[1] See Section 4.3.4 of the Climate Action Reserve Program Manual for an explanation of the Reserve's policies on protocol errata and clarifications. "Errata" are issued to correct typographical errors. "Clarifications" are issued to ensure consistent interpretation and application of the protocol. For document management and program implementation purposes, both errata and clarifications are contained in this single document.

Please ensure that you are using the latest version of this document

Errata and Clarifications (arranged by protocol section)

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Section 5

2. Accounting for Methane Emissions during Temporary Project Shutdown (CLARIFICATION – October 29, 2013) 3
3. Service Providers for Site-Specific Destruction Efficiency Testing (CLARIFICATION – January 21, 2014) 4

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Section 3

1. Regulatory Compliance at Centralized Digesters (CLARIFICATION – July 21, 2016)

Section: 3.6 (Regulatory Compliance)

Context: This section states that, where a verifier determines that project activities have caused a material violation, no CRTs will be issued during the period(s) when the violation occurred. The guidance in this section does not specify how to address regulatory compliance for projects where manure is received from multiple farms and managed in a centralized BCS.

It is unclear whether a violation with respect to one manure source facility would jeopardize the ability of the project to receive credit from emission reductions related to manure from other source facilities. It may be possible for an offset project at a centralized digester to have CRTs issued to it for manure from compliant manure source facilities during a period of time when one or more manure source facilities are materially noncompliant with a regulation.

Clarification: The following text shall be inserted on page 7, at the end of Section 3.6:

"With respect to projects that accept and manage manure from multiple, discrete source facilities (separate from the project BCS in both physical location and management), it may be possible for a project developer to demonstrate that a regulatory violation at one source facility does not affect the eligibility of the entire project under this section. Project developers should contact the Reserve to discuss potential regulatory non-compliance issues."

Section 5

2. Accounting for Methane Emissions during Temporary Project Shutdown (CLARIFICATION – October 29, 2013)

Section: 5.3 (Calculating Project Methane Emissions)

Context: The last full paragraph on page 24 reads: "Although not common under normal digester operation, it is possible that a venting event may occur due to catastrophic failure of digester cover materials, the digester vessel, or the gas collection system. In the event that a catastrophic system failure results in the venting of biogas, the quantity of methane released to the atmosphere shall be estimated according to Equation 5.7 below."

Equation 5.7 on page 26 provides guidance for calculating the quantity of methane released during a venting event, which is added to the total Project Methane Emissions from the BCS, as calculated in Equation 5.6. Equation 5.7 accounts for two releases of biogas: the initial release of biogas being stored in the digester, and then the daily release of additional gas that is generated in the digester until the gas collection system is functional.

The intent of the current guidance is to account for situations where the project digester continues to receive and treat manure, but the gas collection system is discovered to be compromised. In situations where the project digester has been shut down for longer periods of time, biogas is typically released from the digester and then project manure directed to an anaerobic system (e.g. either the covers are taken off the digester or manure is diverted to open lagoons) that would meet the definition in Section 3.4. During such longer shutdowns, it has not been clear whether this entire period of time should be considered a venting event and, if so, how quantification of emissions should proceed.

Clarification: The following text shall be inserted between Equation 5.7 and Equation 5.8 on page 26:

"A venting event occurs when the project digester continues to process manure, but biogas is vented directly to the atmosphere (e.g. through a rip in a lagoon cover or a broken pipe). Projects that experience a venting event shall continue to use Equation 5.7 to calculate the resulting project methane emissions.

A project shutdown occurs when the project digester is no longer functional. This occurs when the project reverts to an open, uncontrolled, anaerobic manure treatment system (e.g. the manure is redirected to open, anaerobic lagoons, or the cover is completely removed from a covered lagoon digester and no heating or mixing occurs). A project shutdown is defined as a venting event on the day of the shutdown, and then a cessation of project operations until the BCS is once again operable.

In the case where the project BCS is shut down and the manure is treated in an open, uncontrolled, anaerobic system (meeting the definition in Section 3.4), the project scenario shall be assumed to be equal to the baseline scenario. In this case the project must quantify the release of stored biogas (MS_{BCS} in Equation 5.7) at the time that the system is shut down, but not the subsequent daily release of biogas from the open lagoons. In these situations the project will cease quantification of emission reductions until the BCS is once again operational."

3. Service Providers for Site-Specific Destruction Efficiency Testing (CLARIFICATION – January 21, 2014)

Section: 5.3 (Calculating Project Methane Emissions)

Context: Footnote 19 on page 25 provides guidelines for service provider accreditation. It is not clear what specific options are available and permissible for projects located in a state or locality which does not have an accreditation program for source test service providers. Footnote 26 on page 29 and the first full paragraph on page 69 in Appendix B contain similar language.

Clarification: The intent of this requirement is to ensure that any source testing conducted for the determination of a site-specific value for methane destruction efficiency is of a quality that would be acceptable for compliance by a regulatory body. The following text shall replace the last sentence of footnote 19 on page 25, of footnote 26 on page 29, and of the first full paragraph on page 69 of Appendix B:

> "If neither the state nor locality relevant to the project site offer accreditation for source testing service providers, projects may use an accredited service provider from another U.S. state or domestic locality. Alternatively, projects may choose a non-accredited service provider, under the following conditions: 1) the service provider must provide verifiable evidence of prior testing which was accepted for compliance by a domestic regulatory agency, and 2) the prior testing procedures must be substantially similar to

the procedures used for determining methane destruction efficiency for the project destruction device(s)."

Section 6

4. Monitoring Operational Status (CLARIFICATION – October 29, 2013)

Section: 6.2 (Biogas Control System Monitoring Requirements)

Context: The first and second paragraphs of page 35 in Section 6.2 states that "[o]perational activity of the destruction devices shall be monitored and documented at least hourly to ensure actual methane destruction. … If for any reason the destruction device or the operational monitoring equipment…is inoperable, then all metered biogas going to the particular device shall be assumed to be released to atmosphere…[and] the destruction efficiency of the device must be assumed to be zero."

Certain types of destruction devices, such as internal combustion engines and most large boiler systems, are designed in such a way that gas may not flow through the device if it is not operational. It has not been clear how the requirements of Section 6.2 apply to these devices.

Clarification: The first sentence of the first paragraph on page 35 shall be read to apply to all destruction devices in use during the reporting period. The paragraph on page 34 of Section 6.2 starting, "[a] single flow meter may be used…," shall not be construed to relax the requirement for hourly operational data for all destruction devices. Rather, that paragraph is allowing a specific metering arrangement during periods when one or more devices are known to be not operating. All destruction devices must have their operational status monitored and recorded at least hourly. If these data are missing or never recorded for a particular device, that device will be assumed to be not operating and will be assigned a destruction efficiency of zero for all flow data that are assigned to that device.

5. Meter Field Check Procedures (CLARIFICATION – October 29, 2013)

Section: 6.3 (Biogas Measurement Instrument QA/QC)

Context: The second paragraph below the first bulleted list of page 36 in Section 6.3 states that "[i]f the field check on a piece of equipment reveals accuracy outside of a +/- 5% threshold, calibration by the manufacturer or a certified service provider is required for that piece of equipment…"

Certain types of biogas flow meters and methane analyzers are susceptible to measurement drift due to buildup of moisture or contaminants on the metering sensor, even if the equipment itself is not out of calibration. If the as-found condition of the meter is outside of the accuracy threshold, but the as-left condition (after cleaning) is within the accuracy threshold, it is not clear whether a full calibration is still required for this piece of equipment. In some cases the manufacturer provides specific guidance to this effect.

Clarification: The following text shall be inserted after the second paragraph following the bulleted list on page 36:

"The as-found condition (percent drift) of a field check must always be recorded. If the meter is found to be measuring outside of the +/- 5% threshold for accuracy, the data must be adjusted for the period beginning with the last successful field check or calibration event up until the meter is confirmed to be in calibration. If, at the time of the failed field check, the meter is cleaned and checked again, with the as-left condition found to be within the accuracy threshold, a full calibration is not required for that piece of equipment. This shall be considered a failed field check, followed by a successful field check. The data adjustment shall be based on the percent drift recorded at the time of the failed field check. However, if the as-left condition remains outside of the +/- 5% accuracy threshold, calibration is required by the manufacturer or a certified service provider for that piece of equipment."

Appendix D

6. Data Substitution when Operational Data are Missing (ERRATUM – October 29, 2013)

Section: Appendix D (Data Substitution)

Context: There are three parameters necessary for the quantification of biogas destruction: biogas flow volume, methane concentration, and operational status of the destruction device. Section D.1 on page 80 provides a methodology for the substitution of missing biogas flow or methane concentration data. Data on the operational status of a destruction device are not eligible for substitution. Substitution of one parameter (i.e. flow or concentration) is only allowed if both other parameters are successfully recorded during the data gap. Thus, to employ the data substitution methodology, it is required that the record of operational status be intact during the gap.

This data substitution methodology was originally developed to resolve incidents of missing methane destruction data in landfill gas projects. Under that project type, excluding the data gap entirely is equivalent to the use of a destruction efficiency (DE) value of zero, whereas the same is not true for a livestock project. In the case of the Livestock Project Protocol, there is additional guidance on page 35 of Section 6.2 that requires the use of a DE value of zero for periods where the destruction device is inoperable, or the operational data are missing. This procedure effectively provides substitution of missing operational data with the assumption that the device was inoperable during the data gap. The effect of this substitution is an increase in project emissions, resulting in a more conservative estimate of emission reductions, regardless of whether the ultimate estimate of emission reductions is based on the modeled baseline or the metered methane destruction.

Because of the nature of the quantification methodology for livestock projects, and the ways that it differs from that of landfill projects, it is appropriate and conservative to carry out flow or methane data substitution, even if the destruction device is inoperable. Under this protocol, the quantification of emission reductions will be more conservative than if the data substitution were not employed.

Correction: The guidance on page 35 of Section 6.2 shall supersede the guidance in Appendix D. The following text shall be inserted after the second paragraph of Section D.1 in Appendix D:

"If the destruction device is inoperable, or its operational data are missing, the destruction efficiency for the device shall be zero during that period of time. Data substitution may be employed for missing biogas flow or methane concentration data during periods of missing operational data, provided the dataset is able to fulfill all other requirements of this data substitution methodology. The data substitution methodology shall be employed in the manner resulting in the greatest level of conservativeness for the quantification of emission reductions."

7. Data Substitution for Continuous Methane Data (CLARIFICATION – October 29, 2013)

Section: Appendix D (Data Substitution)

Context: The data substitution methodology in Appendix D may not be used for data gaps that are greater than seven days. However, the minimum measurement frequency for methane concentration data is once per quarter (three months). For projects that measure methane concentration at a frequency that is greater than quarterly, it is not clear how methane values should be applied during gaps of more than one week but less than an entire quarter.

Clarification: As long as a livestock project has at least one methane concentration reading per quarter, the project may satisfy the monitoring requirements in Section 6.2. A livestock project may have gaps between methane concentration readings that are greater than one week without this being considered "missing data" as it is conceived in Appendix D. Thus, project developers may devise a reasonable approach by which to assign a value to periods of time between recorded methane concentration values. The verifier shall confirm that the value(s) applied by the project is reasonable and conservative. No data substitution may be applied if there are no methane concentration readings during an entire quarter.

CLIMATE ACTION RESERVE

Version 4.0 | January 23, 2013

U.S. Livestock

Project Protocol

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Abbreviations and Acronyms

BCS	Biogas control system
CARB	California Air Resources Board
CH_4	Methane
CNG	Condensed natural gas
CO_2	Carbon dioxide
CRT	Climate Reserve Tonne
EPA	U.S. Environmental Protection Agency
GHG	Greenhouse gas
GWP	Global warming potential
IPCC	Intergovernmental Panel on Climate Change
lb	Pound
LNG	Liquefied natural gas
MCF	Methane conversion factor
MT	Metric ton or tonne
N_2O	Nitrous oxide
NG	Natural gas
QA/QC	Quality Assurance/Quality Control
Reserve	Climate Action Reserve
scf	Standard cubic foot at 1 atm pressure and 60°F temperature
SSR	Sources, sinks, and reservoirs
t	Metric ton or tonne
TAM	Typical animal mass
VS	Volatile solids

1 Introduction

The Climate Action Reserve's (Reserve) Livestock Project Protocol provides guidance to account for and report greenhouse gas (GHG) emission reductions associated with the installation of a biogas control system (BCS) for manure management on dairy cattle and swine farms. The protocol focuses on quantifying the change in methane emissions, but also accounts for potential increases in carbon dioxide emissions.

The Climate Action Reserve is the most experienced, trusted and efficient offset registry to serve the California cap-and-trade program and the voluntary carbon market. With deep roots in California and a reach across North America, the Reserve encourages actions to reduce greenhouse gas emissions and works to ensure environmental benefit, integrity and transparency in market-based solutions to address global climate change. It operates the largest accredited registry for the California compliance market and has played an integral role in the development and administration of the state's cap-and-trade program. For the voluntary market, the Reserve establishes high quality standards for carbon offset projects, oversees independent third-party verification bodies and issues and tracks the transaction of carbon credits (Climate Reserve Tonnes) generated from such projects in a transparent, publicly-accessible system. The Reserve program promotes immediate environmental and health benefits to local communities and brings credibility and value to the carbon market. The Climate Action Reserve is a private 501(c)(3) nonprofit organization based in Los Angeles, California.

Project developers that install manure biogas capture and destruction technologies use this document to register GHG reductions with the Reserve. The protocol provides eligibility rules, methods to calculate reductions, performance-monitoring instructions, and procedures for reporting project information to the Reserve. Additionally, all project reports receive independent verification by Reserve-approved verification bodies. Guidance for verification bodies to verify reductions is provided in the Verification Program Manual and Section 8 of this protocol.

This project protocol facilitates the creation of GHG emission reductions determined in a complete, consistent, transparent, accurate, and conservative manner, while incorporating relevant sources.[1]

[1] See the WRI/WBCSD GHG Protocol for Project Accounting (Part I, Chapter 4) for a description of GHG accounting principles.

2 The GHG Reduction Project

Manure treated and stored under anaerobic conditions decomposes to produce methane, which, if uncontrolled, is emitted to the atmosphere. This predominantly occurs when livestock operations manage waste with anaerobic, liquid-based systems (e.g. in lagoons, ponds, tanks, or pits). Within the livestock sector, the primary drivers of methane generation include the amount of manure produced and the fraction of volatile solids (VS) that decompose anaerobically. Temperature and the retention time of manure during treatment and storage also affect methane production.

2.1 Project Definition

For the purpose of this protocol, the GHG reduction project is defined as the installation and operation of a biogas control system[2] that captures and destroys methane gas from anaerobic manure treatment and/or storage facilities on livestock operations. The biogas control system must destroy methane gas that would otherwise have been emitted to the atmosphere in the absence of the project from uncontrolled anaerobic treatment and/or storage of manure.

Captured biogas can be destroyed on-site, or transported for off-site use (e.g. through gas distribution or transmission pipeline), or used to power vehicles. Regardless of how project developers take advantage of the captured biogas, the ultimate fate of the methane must be destruction.

"Centralized digesters" that integrate waste from more than one livestock operation also meet the definition of a GHG reduction project.

Note that the protocol does not preclude project developers from co-digesting organic matter in the biogas control system. However, the additional organics could impact the nutrient properties of digester effluent; project developers should consider this when assessing the project's associated water quality impacts. The Reserve has also developed the Organic Waste Digestion Project Protocol that provides a quantification methodology for crediting the co-digestion of eligible waste streams with livestock manure. The protocol is available at http://www.climateactionreserve.org/how/protocols/adopted/organic-waste-digestion/current/.

2.2 The Project Developer

The "project developer" is an entity that has an active account on the Reserve, submits a project for listing and registration with the Reserve, and is ultimately responsible for all project reporting and verification. Project developers could be livestock facility owners and operators, GHG project financiers, or other entities. The project developer must have clear ownership of the project's GHG reductions. Ownership of the GHG reductions must be established by clear and explicit title, and the project developer must attest to such ownership each time the project is verified by signing the Reserve's Attestation of Title form.[3]

Under this protocol, the project developer is the only party required to be involved with project implementation.

[2] Biogas control systems encompass anaerobic digester systems – which may be designed and operated in a variety of ways, from ambient temperature covered lagoons to heated lagoons to mesophilic plug flow or complete mix concrete tank digesters—as well as methane destruction systems, such as flares or engines.
[3] Attestation of Title form available at http://www.climateactionreserve.org/how/projects/register/project-submittal-forms/.

3 Eligibility Rules

Project developers using this protocol must satisfy the following eligibility rules to register reductions with the Reserve. The criteria only apply to projects that meet the definition of a GHG reduction project.

Eligibility Rule I:	Location	⟶	*U.S., its territories, and tribal lands*
Eligibility Rule II:	Project Start Date	⟶	*No more than 6 months prior to project submission*
Eligibility Rule III:	Anaerobic Baseline	⟶	*Demonstrate anaerobic baseline conditions*
Eligibility Rule IV:	Additionality	⟶	*Meet performance standard*
		⟶	*Exceed regulatory requirements*
Eligibility Rule V:	Regulatory Compliance	⟶	*Compliance with all applicable laws*

3.1 Location

Only projects located in the United States and its territories, or on U.S. tribal lands, are eligible to register reductions with the Reserve under this protocol. Livestock projects located in Mexico must use the Mexico Livestock Project Protocol if seeking to register GHG reductions with the Reserve.

3.2 Project Start Date

The start date for a livestock project is defined as the date on which the project's biogas control system becomes operational. For the purposes of this protocol, a BCS is considered *operational* on the date that the system begins producing and destroying methane gas following an initial start-up period. This date can be selected by the project developer within the 6 month period following the date on which manure is first loaded into the digester or on the date that the cover installation was completed (for a covered lagoon digester where the lagoon already contained manure).

Projects must be submitted to the Reserve no more than six months after the project start date.

3.3 Project Crediting Period

Project developers are eligible to register GHG reductions with the Reserve according to this protocol for a period of ten years following the project's start date. All projects that initially pass the eligibility requirements set forth in this protocol are eligible to register GHG reductions with the Reserve for the duration of the project's first crediting period (ten years), even if a regulatory agency with authority over a livestock operation passes a rule obligating the installation of a BCS during this initial crediting period.

If a project developer wishes to apply for eligibility under a second crediting period, they must do so within the final six months of the initial crediting period. Thus, the Reserve may issue CRTs for GHG reductions quantified and verified according to the U.S. Livestock Project Protocol for a maximum of two ten year crediting periods after the project start date. Section 3.5.1 and 3.5.2 describe the requirements to qualify for a second crediting period. Deadlines and requirements for reporting and verification, as laid out in this protocol, the Program Manual, and the Verification Program Manual, will continue to apply without interruption.

3.4 Uncontrolled Anaerobic Baseline

The installation of a BCS at a livestock operation where the primary manure management system is aerobic (produces little to no methane) may result in an increase of the amount of methane emitted to the atmosphere. Thus, the BCS must digest manure that would primarily be treated in an anaerobic system in the absence of the project in order for the project to meet the definition of a GHG reduction project. Sections 3.4.1, 3.4.2, and 3.4.3 explain the specific baseline scenario options. Under any one of these scenarios, the uncontrolled anaerobic baseline requirement may be temporarily disrupted for the purposes of construction of the project digester. In these cases, the verifier may use professional judgment to confirm that the requirements of this section have been met.

3.4.1 Existing Livestock Facilities

For livestock facilities that have been in operation for more than five years, developers of livestock projects must demonstrate that an uncontrolled anaerobic manure management system was in place for the five years immediately prior to the date that manure was first loaded into the project digester. That anaerobic system may include a lagoon or a pond as long as the depth of the system was sufficient to prevent algal oxygen production and create an oxygen-free bottom layer (i.e. greater than 1 meter in liquid depth).[4]

For livestock facilities that have been in operation for more than two years, but less than five years, developers of livestock projects must demonstrate that an uncontrolled anaerobic manure management system was in place at all times up until the project's start date.

3.4.2 New Livestock Facilities (Greenfields)

Greenfield livestock projects (i.e. projects that are implemented at livestock facilities that have been in operation for less than two years at a site that had no prior manure management infrastructure) are eligible only if the project developer can demonstrate that there are no restrictions to the construction and operation of an open, uncontrolled, anaerobic manure storage system. Since a greenfield project will not have an existing manure management system that can be used to model the baseline methane emissions, all greenfield projects shall utilize a set of standardized baseline management assumptions (see Table B.10).

3.4.3 Centralized Digesters

For projects that employ a centralized digester that will be accepting manure from more than one livestock operation, each individual source of manure (identified by livestock facility) must meet the anaerobic baseline requirements above as of the project start date. In other words, if a new facility begins sending manure to the project digester after the project start date, the anaerobic baseline of that manure must still be assessed as of the project start date.

[4] This is consistent with the United Nations Framework Convention on Climate Change (UNFCCC) Clean Development Mechanism (CDM) methodology ACM00010 (available at: http://cdm.unfccc.int/methodologies/PAmethodologies/approved.html). For additional information on the design and maintenance of anaerobic wastewater treatment systems, see U.S. Department of Agriculture Natural Resources Conservation Service, Conservation Practice Standard, Waste Storage Facility, No. 313; and U.S. Department of Agriculture Natural Resources Conservation Service, Conservation Practice Standard, Waste Treatment Lagoon, No. 359.

3.5 Additionality

The Reserve will only accept projects that yield surplus GHG reductions that are additional to what would have otherwise occurred. That is, the reductions are above and beyond business-as-usual operation.

Project developers satisfy the "additionality" eligibility rule by passing two tests:

1. The Performance Standard Test
2. The Legal Requirement Test

3.5.1 The Performance Standard Test

Projects pass the Performance Standard Test by meeting a program-wide performance threshold – i.e. a standard of performance applicable to all manure management projects, established on an *ex-ante* basis. The performance threshold represents "better than business-as-usual" manure management. If the project meets the threshold, then it exceeds what would happen under the business-as-usual scenario and generates surplus/additional GHG reductions.

For this protocol, the Reserve uses a technology-specific threshold; sometimes also referred to as a practice-based threshold, where it serves as "best-practice standard" for managing livestock manure. By installing a BCS, a project developer passes the Performance Standard Test.

The Reserve defined this performance standard by evaluating manure management practices in California and the United States. A summary of the study to establish the threshold is provided in Appendix C.

The Performance Standard Test is applied at the time of the project's start date. All projects that pass this test at the project's start date are eligible to register reductions with the Reserve for the duration of the first project crediting period, even if the Reserve revises the Performance Standard Test in subsequent versions of this protocol during that period. As stated in Section 3.3, the project crediting period is ten years.

If a project developer wishes to apply for a second crediting period, the project must meet the eligibility requirements of the most current version of this protocol at the time of the submittal for the second crediting period, including any updates to the Performance Standard Test.

3.5.2 The Legal Requirement Test

All projects are subject to a Legal Requirement Test to ensure that the GHG reductions achieved by a project would not otherwise have occurred due to federal, state, or local regulations, or other legally binding mandates. A project passes the Legal Requirement Test when there are no laws, statutes, regulations, court orders, environmental mitigation agreements, permitting conditions, or other legally binding mandates requiring the installation of a BCS at the livestock operation.

The Legal Requirement Test is applied at the time of a project's start date. To satisfy the Legal Requirement Test, project developers must submit a signed Attestation of Voluntary Implementation form[5] prior to the commencement of verification activities for the first verification

[5] Attestation forms are available at http://www.climateactionreserve.org/how/projects/register/project-submittal-forms/.

period. All projects that pass this test at the project's start date are eligible to register reductions with the Reserve for the duration of their first crediting period, even if legal requirements change or new legal requirements are enacted during that period.

If a project developer wishes to apply for a second crediting period, the project must meet the eligibility requirements of the most current version of this protocol, including any updates to the Legal Requirement Test. Furthermore, during a project's second crediting period, it must demonstrate that it passes the Legal Requirement Test during each reporting period. To satisfy the Legal Requirement Test, project developers must submit a signed Attestation of Voluntary Implementation form prior to the commencement of verification activities for each verification period. If project activities become legally required during a project's second crediting period, the project will only be eligible to receive CRTs up to the date that the system is required to be operational.

The Reserve's analysis of manure management practices in the U.S. identified no regulations that obligate livestock owners to invest in a manure BCS. The analysis looked most closely at recent, stringent California air quality regulations (e.g. SJVAPCD Rule 4570 and Sacramento AQMD Rule 496), and found that installing an anaerobic digester is one of several compliance options, although high capital costs appear to prohibit the use of anaerobic digesters as a practical compliance mechanism for these air quality regulations.

3.6 Regulatory Compliance

As a final eligibility requirement, project developers must attest that project activities do not cause material violations of applicable laws (e.g. air, water quality, safety, etc.). To satisfy this requirement, project developers must submit a signed Attestation of Regulatory Compliance form[6] prior to the commencement of verification activities each time the project is verified. Project developers are also required to disclose in writing to the verifier any and all instances of legal violations – material or otherwise – caused by the project or project activities.

A violation should be considered to be "caused" by project activities if it can be reasonably argued that the violation would not have occurred in the absence of the project activities. If there is any question of causality, the project developer shall disclose the violation to the verifier.

If a verifier finds that project activities have caused a material violation, then CRTs will not be issued for GHG reductions that occurred during the period(s) when the violation occurred. Individual violations due to administrative or reporting issues, or due to "acts of nature," are not considered material and will not affect CRT crediting. However, recurrent administrative violations directly related to project activities may affect crediting. Verifiers must determine if recurrent violations rise to the level of materiality. If the verifier is unable to assess the materiality of the violation, then the verifier shall consult with the Reserve.

[6] Attestation forms are available at http://www.climateactionreserve.org/how/projects/register/project-submittal-forms/.

4 The GHG Assessment Boundary

The GHG Assessment Boundary delineates the GHG sources, sinks, and reservoirs (SSRs) that shall be assessed by project developers to determine the net change in emissions associated with installing a BCS. This protocol's assessment boundary captures sources from waste production to disposal, including off-site manure disposal.

CH_4 emissions from the land application of manure and digester effluent are excluded from the GHG Assessment Boundary. As these emission sources will either remain the same or decrease from the baseline to the project scenario, this exclusion is considered to be conservative.

N_2O emissions associated with manure management and disposal are also excluded from the GHG Assessment Boundary. Again, as these emission sources will either remain the same or decrease from the baseline to the project scenario, this exclusion is also considered to be conservative. Significant uncertainty remains regarding the quantification of potential N_2O changes. While some projects may result in a significant decrease in N_2O emissions, at this time there is no project-level methodology available to appropriately account for this uncertainty.

CO_2 emissions associated with the capture and destruction of biogas are considered biogenic emissions[7] (as opposed to anthropogenic) and are not included in the GHG Assessment Boundary.

This protocol does not account for CO_2 emission reductions associated with displacing grid-delivered electricity or fossil fuel use. However, project developers may reduce the project emissions associated with increased use of grid-connected electricity by utilizing project-generated electricity for project equipment.

Figure 4.1 provides a general illustration of the GHG Assessment Boundary, indicating which SSRs are included or excluded from the boundary. All SSRs within the dashed line are accounted for under this protocol.

Table 4.1 provides greater detail on each SSR and provides justification for the inclusion or exclusion of SSRs and gases from the GHG Assessment Boundary.

[7] The rationale is that carbon dioxide emitted during combustion represents the carbon dioxide that would have been emitted during natural decomposition of the manure. Emissions from the biogas control system do not yield a net increase in atmospheric carbon dioxide because they are theoretically equivalent to the carbon dioxide absorbed during plant/feed growth.

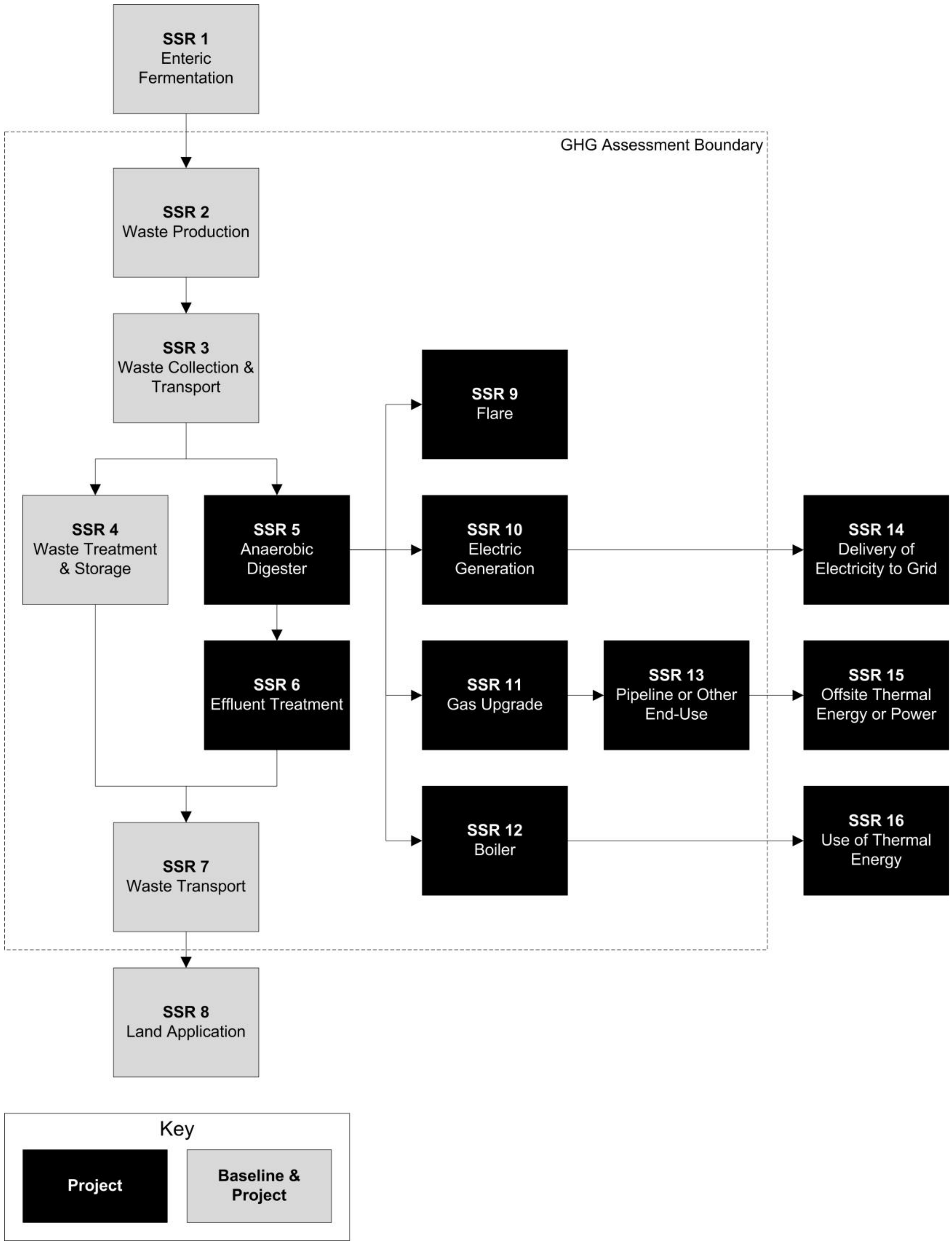

Figure 4.1. General Illustration of the GHG Assessment Boundary

Table 4.1 relates GHG source categories to sources and gases, and indicates inclusion in the calculation methodology. It is intended to be illustrative – GHG sources are indicative for the source category, GHGs in addition to the main GHG are also mentioned, where appropriate.

Table 4.1. Description of all Sources, Sinks, and Reservoirs

SSR	GHG Source	Gas	Relevant to Baseline (B) or Project (P)	Included/ Excluded	Justification/Explanation
1	Emissions from enteric fermentation	CH_4	B, P	*Excluded*	It is very unlikely that a livestock operation would change its feeding strategy to maximize biogas production from a digester; thus impacting enteric fermentation emissions from ruminant animals.
2	Emissions from waste deposits in barn, milking parlor or pasture/corral	N_2O	B, P	*Excluded*	This exclusion is conservative as emissions will either remain the same or decrease from the baseline to the project scenario, see page 8 for further explanation.
	Emissions from mobile and stationary support equipment	CO_2	B, P	*Included*	If any additional vehicles or equipment are required by the project beyond what is required in the baseline, emissions from such sources shall be accounted for.
		CH_4		*Excluded*	Emission source is assumed to be very small.
		N_2O		*Excluded*	Emission source is assumed to be very small.
3	Emissions from mechanical systems used to collect and transport waste (e.g. engines and pumps for flush systems; vacuums and tractors for scrape systems)	CO_2	B, P	*Included*	If any additional vehicle or equipment use is required by the project beyond what is required in the baseline, emissions from such sources shall be accounted for.
		CH_4		*Excluded*	Emission source is assumed to be very small.
		N_2O		*Excluded*	Emission source is assumed to be very small.
	Vehicle emissions (e.g. for centralized digesters)	CO_2		*Included*	If any additional vehicles or fuel use is required by the project beyond what is required in the baseline, emissions from such equipment shall be accounted for.
		CH_4		*Excluded*	Emission source is assumed to be very small.
		N_2O		*Excluded*	Emission source is assumed to be very small.

SSR	GHG Source	Gas	Relevant to Baseline (B) or Project (P)	Included/ Excluded	Justification/Explanation
4	Emissions from waste treatment and storage including: anaerobic lagoons, dry lot deposits, compost piles, solid storage piles, manure settling basins, aerobic treatment, storage ponds, etc.	CO_2	B, P	*Excluded*	Biogenic emissions are excluded.
		CH_4		*Included*	Primary source of emissions in the baseline.
		N_2O		*Excluded*	This exclusion is conservative as emissions will either remain the same or decrease from the baseline to the project scenario, see page 8 for further explanation.
	Emissions from support equipment	CO_2		*Included*	If any additional equipment is required by the project beyond what is required in the baseline, emissions from such equipment shall be accounted for.
		CH_4		*Excluded*	Emission source is assumed to be very small.
		N_2O		*Excluded*	Emission source is assumed to be very small.
5	Emissions from the anaerobic digester due to biogas collection inefficiencies and venting events	CH_4	P	*Included*	Project may result in leaked emissions from anaerobic digester.
6	Emissions from effluent treatment system	CH_4	P	*Included*	Primary source of emissions from project activities.
		N_2O		*Excluded*	See page 8.
7	Vehicle emissions for land application and/or off-site transport	CO_2	B, P	*Included*	If any additional vehicle use is required by the project beyond what is required in the baseline, associated additional emissions shall be accounted for.
		CH_4		*Excluded*	Emission source is assumed to be very small.
		N_2O		*Excluded*	Emission source is assumed to be very small.
8	Emissions from land application	CH_4	B, P	*Excluded*	Project activity is unlikely to increase emissions relative to baseline activity.
		N_2O	B, P	*Excluded*	This exclusion is conservative as emissions will either remain the same or decrease from the baseline to the project scenario, see page 8 for further explanation

SSR	GHG Source	Gas	Relevant to Baseline (B) or Project (P)	Included/ Excluded	Justification/Explanation
9	Emissions from combustion during flaring, including emissions from incomplete combustion of biogas	CO_2	P	*Excluded*	Biogenic emissions are excluded.
		CH_4		*Included*	Primary source of emissions from project activities.
		N_2O		*Excluded*	Emission source is assumed to be very small.
10	Emissions from combustion during electric generation, including incomplete combustion of biogas	CO_2	P	*Excluded*	Biogenic emissions are excluded.
		CH_4		*Included*	Primary source of emissions from project activities.
		N_2O		*Excluded*	Emission source is assumed to be very small.
11	Emissions from upgrading biogas for pipeline injection or use as CNG/LNG fuel	CO_2	P	*Included*	Emissions resulting from on-site fossil fuel use and/or grid electricity may be significant.
		CH_4		*Excluded*	Emission source is assumed to be very small.
		N_2O		*Excluded*	Emission source is assumed to be very small.
12	Emissions from combustion at boiler, including emissions from incomplete combustion of biogas	CO_2	P	*Excluded*	Biogenic emissions are excluded.
		CH_4		*Included*	Primary source of emissions from project activities.
		N_2O		*Excluded*	Emission source is assumed to be very small.
13	Emissions from combustion of biogas by end user of pipeline or CNG/LNG, including incomplete combustion	CO_2	P	*Excluded*	Biogenic emissions are excluded.
		CH_4		*Included*	Primary source of emissions from project activities.
		N_2O		*Excluded*	Emission source is assumed to be very small.
14	Use of project-generated electricity	CO_2 CH_4 N_2O	P	*Excluded*	This protocol does not cover displacement of GHG emissions from the use of biogas-generated electricity.
15	Off-site use of project-generated thermal energy or power	CO_2 CH_4 N_2O	P	*Excluded*	This protocol does not cover displacement of GHG emissions from the use of biogas delivered through pipeline or other end uses.
16	Use of project-generated thermal energy	CO_2 CH_4 N_2O	P	*Excluded*	This protocol does not cover displacement of GHG emissions from the use of biogas-generated thermal energy.
	Project construction and decommissioning emissions	CO_2 CH_4 N_2O	P	*Excluded*	Emission source is assumed to be very small.

5 Quantifying GHG Emission Reductions

GHG emission reductions from a livestock project are quantified by comparing actual project emissions to baseline emissions at the project site. Baseline emissions are an estimate of the GHG emissions from sources within the GHG Assessment Boundary (see Section 4) that would have occurred in the absence of the livestock project. Project emissions are actual GHG emissions that occur at sources within the GHG Assessment Boundary during the reporting period. Project emissions must be subtracted from the baseline emissions to quantify the project's total net GHG emission reductions (Equation 5.1).

GHG emission reductions are generally quantified and verified on an annual basis. Project developers may choose to verify GHG emission reductions on a more frequent or less frequent basis if they desire (see Section 7.3). The length of time over which GHG emission reductions are quantified and reported to the Reserve is called the "reporting period." The length of time over which GHG reductions are verified is called a "verification period." Under this protocol, a verification period may cover multiple reporting periods (see Section 7.3.4). Project developers should take note that some equations to calculate baseline and project emissions are run on a month-by-month basis and activity data monitoring takes place at varying levels of frequency. As applicable, monthly emissions data (for baseline and project) are summed together to calculate emission reductions over a given reporting period. Projects whose reporting periods begin or end with incomplete calendar months shall only quantify the baseline and project emissions for the portion of the month that is included within the reporting period.
The calculations provided in this protocol are derived from internationally accepted methodologies.[8] Project developers shall use the calculation methods provided in this protocol to determine baseline and project GHG emissions in order to quantify GHG emission reductions.

To support project developers and facilitate consistent and complete emissions reporting, the Reserve has developed an Excel-based calculation tool. This tool is available to all Reserve account holders and their designated representatives. Instructions for obtaining the most recent version of this tool are available on the U.S. Livestock Project Protocol webpage. The Reserve *recommends* the use of the Livestock Calculation Tool for all project calculations and emission reduction reports. Only the most recent version of this tool should be used, unless otherwise recommended by Reserve staff. In any case where there is potential disagreement between guidance provided in the protocol and guidance provided in the calculation tool, the protocol shall take precedence.

The current methodology for quantifying the GHG impact associated with installing a BCS requires the use of both modeled reductions (following Equation 5.2 to Equation 5.4 and Equation 5.6 to Equation 5.9) as well as the utilization of *ex-post* metered data from the BCS to be used as a check on the modeled reductions.

The Reserve recognizes that there can be material differences between modeled methane emission reductions and the actual metered quantity of methane that is captured and destroyed by the BCS due to digester start-up periods, venting events, and other BCS operational issues.

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[8] The Reserve's GHG reduction calculation method is derived from the Kyoto Protocol's Clean Development Mechanism (ACM0010 V.5), the EPA's Climate Leaders Program (Manure Offset Protocol, August 2008), and the RGGI Model Rule (January 5, 2007).

These operational issues have the potential to result in substantially less methane destruction than is modeled, leading to an overestimation of GHG reductions in the modeled case.

To address this issue and maintain consistency with international best practice, the Reserve requires the modeled methane emission reduction results to be compared to the *ex-post* metered quantity of methane that is captured and destroyed by the BCS. The lesser of the two values will represent the total methane emission reductions for the reporting period. Equation 5.1 below outlines the quantification approach for calculating the emission reductions from the installation of a BCS.

5.1 Required Parameters for Modeling Baseline and Project Emissions

The following parameters must be determined for the modeling of baseline and project emissions:

Population – P_L

The procedure requires project developers to differentiate between livestock categories (*L*) (e.g. lactating dairy cows, non-milking dairy cows, heifers, etc.). This accounts for differences in methane generation across livestock categories. See Appendix B, Table B.2 for methane generation values. The population of each livestock category shall be monitored on a monthly basis, and for Equation 5.4 is averaged for an annual total population.

Volatile solids – VS_L

This value represents the daily organic material in the manure for each livestock category and consists of both biodegradable and non-biodegradable fractions. The VS content of manure is a combination of excreted fecal material (the fraction of a livestock category's diet consumed and not digested) and urinary excretions, expressed in a dry matter weight basis (kg/animal).[9] This protocol requires that the VS value for all livestock categories be determined as outlined in Box 5.1.

$Mass_L$

This value is the annual average live weight of the animals, per livestock category. These data are necessary because default VS values are supplied in units of kg/day/1000kg mass, therefore the average mass of the corresponding livestock category is required in order to convert the units of VS into kg/day/animal. Site specific livestock mass is preferred for all livestock categories. If site-specific data are unavailable, Typical Animal Mass (TAM) values may be used (see Appendix B, Table B.2).

Maximum methane production – $B_{0,L}$

This value represents the maximum methane-producing capacity of the manure, differentiated by livestock category (*L*) and diet. Project developers shall use the default B_0 factors from Appendix B, Table B.3. Alternatively, project developers may follow the sampling and testing procedure contained in Section 6.1 in order to determine a site-specific B_0 value for a particular animal category.

[9] IPCC 2006 Guidelines volume 4, chapter 10, p. 10.42.

MS_S

The MS value apportions manure from each livestock category to appropriate manure management system component (*S*), and is a critical factor in determining a project baseline, as well as project emissions from effluent treatment. It reflects the reality that waste from the operation's livestock categories are not managed uniformly. The MS value accounts for the operation's multiple types of manure management systems. It is expressed as a percent (%), relative to the total amount of VS produced by the livestock category. As waste production is normalized for each livestock category, the percentage shall be calculated as percent of population for each livestock category. For example, a dairy operation might send 85% of its milking cows' waste to an anaerobic lagoon and 15% could be deposited in a corral. In this situation, an MS value of 85% would be assigned to Equation 5.3 and 15% to Equation 5.4.

Importantly, the MS value indicates where the waste would have been managed in the baseline scenario. If a portion of the VS was removed from the waste stream through some sort of separation procedure, the MS value shall be adjusted to accurately reflect the baseline treatment of the VS. To account for VS removal from solids separation equipment, project developers may use a default value for the particular type of separation mechanisms employed (Table B.9), or a site-specific value based on the removal efficiency of the baseline system.

MS_{BCS}, which represents the fraction of manure that is sent to the BCS in the project scenario, follows the same logic as above, but is used to accurately quantify the project methane emissions from effluent treatment (see Equation 5.8).

MGS_{BCS}

The MGS_{BCS} value represents the maximum biogas storage capacity of the BCS system. This value is needed only in the case of a venting event during the reporting period, which is quantified using Equation 5.7. If the BCS consists of multiple digester tanks or covered lagoons, the project only need quantify the maximum storage (MGS_{BCS}) and biogas flow (F_{pw}) of the component(s) of the BCS that experienced the venting event.

Methane conversion factor – MCF

This method to calculate methane emissions reflects the site-specific monthly biological performance of the operation's baseline anaerobic manure management systems, as predicted using the van't Hoff-Arrhenius equation and farm-level data on temperature, as well as VS loading and system VS retention time.[10]

Each manure management system component has a volatile solids-to-methane conversion efficiency that represents the degree to which maximum methane production (B_0) is achieved. Methane production is a function of the extent of anaerobic conditions present in the system, the temperature of the system, and the retention time of organic material in the system.[11]

Default MCF values for non-anaerobic baseline manure management system components (as well as certain project BCS effluent treatment and Non-BCS sources) are available in Appendix B. These are used in Equation 5.4 and Equation 5.9.

Contrastingly, site-specific calculations of volatile solids-to-methane conversion efficiency are required for anaerobic baseline manure management system components and for the anaerobic

[10] The method is derived from Mangino et al., "Development of a Methane Conversion Factor to Estimate Emissions from Animal Waste Lagoons" (2001).
[11] IPCC 2006 Guidelines volume 4, chapter 10, p. 10.43.

treatment of project BCS effluent. For anaerobic lagoons, storage ponds, liquid slurry tanks etc., project developers perform a site-specific calculation of the mass of volatile solids degraded by the anaerobic storage/treatment system. This is expressed as "degraded volatile solids" or VS_{deg} in Equation 5.3, which equals the system's monthly available volatile solids multiplied by '*f*', the van't Hoff-Arrhenius factor. The '*f*' factor effectively converts total available volatile solids in the anaerobic manure storage/treatment system to methane-convertible volatile solids, based on the monthly temperature of the system. The multiplication of VS_{deg} by B_0 quantifies the maximum potential methane emissions that would have been produced for each livestock category's contribution of manure to that system.

Equation 5.1 GHG Reductions from Installing a Biogas Control System

$$ER = min\{ER_{modeled}, ER_{metered}\}$$

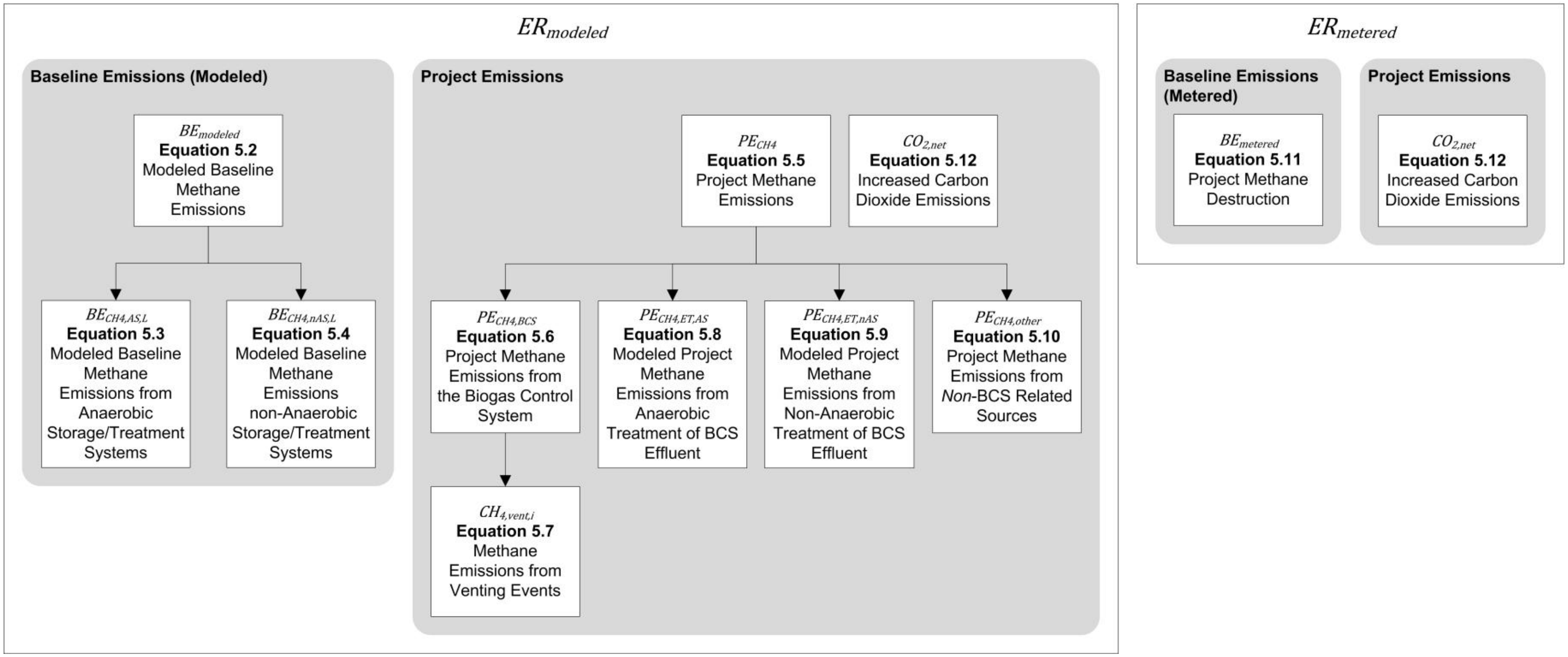


Figure 5.1. Organization of Equations in Section 5

Equation 5.1. GHG Reductions from Installing a Biogas Control System

$$ER = \min\{ER_{modeled}, ER_{metered}\}$$

$$ER_{modeled} = BE_{modeled} - PE_{CH_4} - CO_{2,net}$$

Where, Units

$ER_{modeled}$	=	Avoided methane emissions associated with the project during the reporting period, quantified using a modeled baseline scenario	tCO_2e
$BE_{modeled}$	=	Modeled baseline emissions from the baseline scenario (Equation 5.2)	tCO_2e
PE_{CH4}	=	Total project methane emissions during the reporting period (Equation 5.5)	tCO_2e
$CO_{2,net}$	=	Net increase in anthropogenic CO_2 emissions from electricity consumption and mobile and stationary combustion sources resulting from project activity (Equation 5.12)	tCO_2e

$$ER_{metered} = BE_{metered} - CO_{2,net}$$

Where, Units

$ER_{metered}$	=	Avoided methane emissions associated with the project during the reporting period, quantified using metered methane destruction data	tCO_2e
$BE_{metered}$	=	Aggregated quantity of methane collected and destroyed during the reporting period (Equation 5.11)	tCO_2e
$CO_{2,net}$	=	Net increase in anthropogenic CO_2 emissions from electricity consumption and mobile and stationary combustion sources resulting from project activity (Equation 5.12)	tCO_2e

5.2 Modeling Baseline Methane Emissions

Baseline emissions represent the GHG emissions within the GHG Assessment Boundary that would have occurred if not for the installation of the BCS. For the purposes of this protocol, project developers calculate their baseline emissions according to the manure management system in place prior to installing the BCS. Baseline emissions are then recalculated for each reporting period to reflect what the emissions would have been had the previous management system continued to function under current conditions. For Greenfield projects, as defined in Section 3.4.2, the baseline manure management practices shall be modeled according to the default values provided in Table B.10.

The procedure to determine the modeled baseline methane emissions follows Equation 5.2, which combines Equation 5.3 and Equation 5.4. The calculation procedures use a combination of site-specific values and default factors.

Box 5.1. Daily Volatile Solids for All Livestock Categories

Consistent with international best-practice, it is recommended that appropriate VS_L values for dairy livestock categories be obtained from the state-specific lookup tables (Tables B.5.a – B.5.f) provided in Appendix B. When possible, use the year corresponding to the appropriate emission year. If the current year's table is not included in the protocol, use the most current year that is available from the Reserve. Updated tables will be provided in the Livestock Calculation Tool, as well as the Reserve website.[12]

VS_L values for all other livestock can be found in Appendix B, Table B.3.

Important – Units provided for all VS values in Appendix B are in (kg/day/1000kg), In order to get VS_L in the appropriate units (kg/animal/day), the following equation must be used:

$$\boldsymbol{VS_L = VS_{Table} \times \frac{Mass_L}{1000}}$$

Where,			Units
VS_L	=	Volatile solid excretion on a dry matter weight basis	kg/animal/day
VS_{Table}	=	Volatile solid excretion from lookup table (Table B.3 and Table B.5a - B.5d)	kg/day/1000kg
$Mass_L$	=	Average live weight for livestock category *L*. If site specific data are unavailable, use values from Appendix B, Table B.2 corresponding to the appropriate emission year (or the most current year that is available from the Reserve)	kg

Equation 5.2. Modeled Baseline Methane Emissions

$$\boldsymbol{BE_{modeled} = \sum_{S,L}\left(BE_{CH_4,AS,L} + BE_{CH_4,nAS,L}\right)}$$

Where,			Units
$BE_{modeled}$	=	Total baseline methane emissions during the reporting period, summed for each baseline treatment system *S* and livestock category *L*	tCO_2e
$BE_{CH4,AS,L}$	=	Total monthly baseline methane emissions from anaerobic storage/treatment system *AS* by livestock category *L*, aggregated for the reporting period. See Equation 5.3	tCO_2e
$BE_{CH4,nAS,L}$	=	Total baseline methane emissions for the reporting period from non-anaerobic storage/treatment systems by livestock category *L.* See Equation 5.4	tCO_2e

[12] http://www.climateactionreserve.org/how/protocols/us-livestock/

Equation 5.3. Modeled Baseline Methane Emissions from Anaerobic Storage/Treatment Systems

$$BE_{CH_4,AS,L} = \left(VS_{deg,AS,L} \times B_{0,L} \times days_{mo} \times 0.68 \times 0.001 \times 21\right) \times \left(\frac{rd_{mo}}{days_{mo}}\right)$$

Where,

			Units
$BE_{CH4,AS,L}$	=	Total monthly baseline methane emissions from anaerobic manure storage/treatment system *AS* from livestock category *L*	tCO_2e/yr
$VS_{deg,AS,L}$	=	Monthly volatile solids degraded in anaerobic manure storage/treatment system *AS* from livestock category *L*	kg dry matter
$B_{0,L}$	=	Maximum methane producing capacity of manure for livestock category *L* – see Appendix B, Table B.3 for default values or Section 6.1 for guidance on determining a site-specific value	m^3 CH_4/kg of VS
0.68	=	Density of methane (1 atm, 60°F)	kg/m^3
0.001	=	Conversion factor from kg to metric tons	
21	=	Global Warming Potential of methane as carbon dioxide equivalent	tCO_2e/tCH_4
$days_{mo}$	=	Calendar days per month	days
rd_{mo}	=	Reporting days during the current month (see Box 5.2)	days

$$VS_{deg,AS,L} = \sum_{AS,L} \left(VS_{avail,AS,L} \times f\right)$$

Where,

			Units
$VS_{deg,AS,L}$	=	Monthly volatile solids degraded by anaerobic manure storage/ treatment system *AS* by livestock category *L*	kg dry matter
$VS_{avail,AS,L}$	=	Monthly volatile solids available for degradation from anaerobic manure storage/treatment system *AS* by livestock category *L*	kg dry matter
f	=	The van't Hoff-Arrhenius factor = "the proportion of volatile solids that are biologically available for conversion to methane based on the monthly temperature of the system" [13]	

Equation 5.3 continued on next page.

[13] Mangino, et al.

Equation 5.3. Continued

$$VS_{avail,AS,L} = \left(VS_L \times P_L \times MS_{AS,L} \times days_{mo} \times 0.8\right) + \left(VS_{avail-1,AS} - VS_{deg-1,AS}\right)$$

Where,			Units
$VS_{avail,AS,L}$	=	Monthly volatile solids available for degradation in anaerobic storage/treatment system *AS* by livestock category *L*	kg dry matter
VS_L	=	Volatile solids produced by livestock category *L* on a dry matter basis. Refer to Box 5.1 for guidance on using appropriate units for VS_L values from Appendix B	kg/animal/day
P_L	=	Average population of livestock category *L* (based on population data for the current month)	
$MS_{AS,L}$	=	Percent of manure sent to (managed in) anaerobic manure storage/treatment system *AS* from livestock category *L* [14]	%
$days_{mo}$	=	Calendar days per month	days
0.8	=	Management and design practices factor[15]	
$VS_{avail-1,AS}$	=	Previous month's volatile solids available for degradation in anaerobic system *AS*[16]	kg
$VS_{deg-1,AS}$	=	Previous month's volatile solids degraded by anaerobic system *AS*	kg

$$f = exp\left[\frac{E(T_{mo} - T_{ref})}{(R)(T_{ref})(T_{mo})}\right]$$

Where,			Units
f	=	The van't Hoff-Arrhenius factor	
E	=	Activation energy constant (15,175)	cal/mol
T_{mo}	=	Monthly average ambient temperature (K = °C + 273). If T_{mo} < 5°C then *f* = 0.104. If T_{mo} > 29.5°C then *f* = 0.95	Kelvin
T_{ref}	=	303.16; Reference temperature for calculation	Kelvin
R	=	Ideal gas constant (1.987)	cal/Kmol

[14] The MS value represents the percent of manure that would be sent to (managed by) the anaerobic manure storage/treatment systems in the baseline case – as if the biogas control system was never installed.
[15] Mangino, et al. This factor was derived to "account for management and design practices that result in the loss of volatile solids from the management system." This reflects the difference between the theoretical modeled biological activity and empirical measurement of biological activity due to removal of liquid or other management practices that result in loss of VS from the treatment system. This does not account for removal of solids prior to the treatment system.
[16] IPCC 2006 Guidelines (Volume 4, Chapter 10, p. 42); ACM0010 (V2, p.8); and EPA Climate Leaders Manure Offset Protocol (August 2008).

Box 5.2. Calculating the Number of Reporting Days for a Reporting Period

For some projects, it may be necessary to exclude a number of days from the calculation of emission reductions. If the reporting period begins or ends mid-way through a month, the calculation shall be prorated to only include the number of days for each month that fall within the reporting period by setting *nrd* equal to the number of days that fall outside the reporting period. If the project is not eligible to report emission reductions for a certain period of time for other reasons (e.g. regulatory compliance issues, missing data), those days may also be included in the determination of *nrd*.

For example, if a reporting period begins on March 10, then nrd_{March} = 9. If the same reporting period ends on December 31st of the same year, then nrd_{rp} = 9, and *rd* = (306 – 9) = 297.

The following equation is used to determine the number of reporting days for the current period. This is to be applied for individual months for those equations that are run monthly, and for the entire reporting period for those equations that are run once per reporting period.

$$\boldsymbol{rd = days - nrd}$$

Where,

rd	=	Number of reporting days in the current period (month, reporting period, etc.)
days	=	Number of calendar days in the current period (e.g. equal to 30 for June)
nrd	=	Non-reporting days in the current period

Retention of Volatile Solids

Equation 5.3 calculates methane emissions from anaerobic manure storage/treatment systems based on site-specific information on the mass of volatile solids degraded by the anaerobic storage/treatment system and available for methane conversion.[17] It incorporates the effects of temperature through the van't Hoff-Arrhenius (*f*) factor and accounts for the retention of volatile solids through the use of monthly assumptions of baseline conditions. Each month, a certain quantity of VS is converted into methane (VS_{deg}). The VS that is available for conversion each month (VS_{avail}) is the sum of VS that enters the manure management system, as well as VS that remains in the system from the previous month ($VS_{avail-1} – VS_{deg-1}$).

Project developers shall not carry over volatile solids from one month to the next when modeling baseline anaerobic treatment systems where the retention time was 30 days or less. For these systems ($VS_{avail-1} – VS_{deg-1}$) = 0 in Equation 5.3 for every month.

Depending on the accumulation of sludge in the baseline manure storage system, it may have been necessary to drain and clean the system on a periodic basis. This cleaning removes the non-degraded VS that has accumulated in the system. For anaerobic lagoons with a retention time greater than 30 days, project developers shall zero out the VS retained in the system following the month when the system would have been completely drained and sludge removed under baseline operating conditions. For the month following the sludge removal, ($VS_{avail-1} – VS_{deg-1}$) = 0 in Equation 5.3. For projects where a BCS is being retrofit into existing operations, baseline anaerobic system management practices should reflect actual pre-project manure management practices on that farm.

[17] These system components must meet the Anaerobic Baseline requirement in Section 3.4.

If the farm utilized solids separation in the baseline (thus preventing or delaying sludge accumulation), this removal and alternative treatment of VS should be reflected in the MS values, as explained earlier in this section.

The removal of supernatant liquids for spraying on fields at agronomic rates does not affect the monthly carryover of VS, as long as the system maintains at least one meter of liquid depth. Projects therefore do not need to account for regular field spraying activities that meet this description.

Equation 5.4 applies to non-anaerobic storage/treatment systems. Both Equation 5.3 and Equation 5.4 reflect basic biological principles of methane production from available volatile solids, determine methane generation for each livestock category, and account for the extent to which the waste management system handles each category's manure.

Equation 5.4. Modeled Baseline Methane for Non-Anaerobic Storage/Treatment Systems

$$BE_{CH_4,nAS,L} = \left(P_L \times MS_{L,nAS} \times VS_L \times days_{rp} \times MCF_{nAS} \times B_{0,L}\right) \times 0.68 \times 0.001 \times 21 \times \left(\frac{rd_{rp}}{days_{rp}}\right)$$

Where,

			Units
$BE_{CH4,nAS,L}$	=	Total baseline methane emissions during the reporting period from non-anaerobic storage/treatment systems	tCO_2e
P_L	=	Average population of livestock category *L* during the reporting period (based on monthly population data)	
$MS_{L,nAS}$	=	Percent of manure from livestock category *L* managed in non-anaerobic storage/treatment systems	%
VS_L	=	Volatile solids produced by livestock category *L* on a dry matter basis. Refer to Box 5.1 for guidance on using appropriate units for VS_L values from Appendix B	kg/animal/day
$days_{rp}$	=	Number of days in the reporting period	days
MCF_{nAS}	=	Methane conversion factor for non-anaerobic storage/treatment system. See Appendix B	%
$B_{0,L}$	=	Maximum methane producing capacity for manure for livestock category *L*. See Appendix B, Table B.3 for default values, or Section 6.1 for determining a site-specific value	m^3 CH_4/kg of VS dry matter
0.68	=	Density of methane (1 atm, 60°F)	kg/m^3
0.001	=	Conversion factor from kg to metric tons	
21	=	Global Warming Potential of methane as carbon dioxide equivalent	tCO_2e/tCH_4
rd_{rp}	=	Reporting days during the reporting period	days

5.3 Calculating Project Methane Emissions

Project emissions are actual GHG emissions that occur within the GHG Assessment Boundary after the installation of the BCS. Project emissions are calculated on an annual, *ex-post* basis. Like baseline emissions, some parameters are monitored on a monthly basis. Unlike baseline emission calculations, methane emissions from the BCS are calculated from metered data, rather than modeled projections. Methane emissions from manure storage and/or treatment systems other than the BCS are modeled much the same as in the baseline scenario.

As shown in Equation 5.5, project methane emissions equal:

- The amount of methane created by the BCS that is not captured and destroyed by the control system, plus
- Methane from the digester effluent treatment systems (where applicable), plus
- Methane from sources in the waste treatment and storage category other than the BCS and associated effluent treatment systems. This includes all other manure treatment systems such as compost piles, solids storage etc.

Consistent with this protocol's baseline methane calculation approach, the formula to account for project methane emissions incorporates all potential sources within the waste treatment and storage category. Non-BCS-related sources follow the same calculation approach as provided in the baseline methane equations. Several activity data for the variables in Equation 5.9 will be the same as those in Equation 5.2 to Equation 5.4.

If the project elects to install an impermeable cover on an effluent pond (potentially creating an additional anaerobic digester) and the biogas generated in this covered pond is collected and destroyed by the project BCS, then this covered pond shall be considered part of the project digester system. If the biogas generated by this covered pond is not destroyed, it must be quantified as project methane emissions using Equation 5.8.

Although not common under normal digester operation, it is possible that a venting event may occur due to catastrophic failure of digester cover materials, the digester vessel, or the gas collection system. In the event that a catastrophic system failure results in the venting of biogas, the quantity of methane released to the atmosphere shall be estimated according to Equation 5.7 below.

Equation 5.5. Project Methane Emissions

$$PE_{CH_4} = \left(PE_{CH_4,BCS} + PE_{CH_4,ET,AS} + PE_{CH_4,ET,nAS} + PE_{CH_4,other}\right) \times 21$$

Where,

			Units
PE_{CH4}	=	Total project methane emissions for the reporting period,	tCO_2e
$PE_{CH4,BCS}$	=	Methane emissions from the BCS during the reporting period (Equation 5.6)	tCH_4
$PE_{CH4,ET,AS}$	=	Monthly methane emissions from the BCS effluent anaerobic treatment systems, aggregated for the reporting period (Equation 5.8)	tCH_4
$PE_{CH4,ET,nAS}$	=	Methane emissions from the BCS effluent non-anaerobic treatment systems during the reporting period (Equation 5.9)	tCH_4
$PE_{CH4,other}$	=	Methane emissions from sources in the waste treatment and storage category other than the BCS and associated effluent treatment systems, during the reporting period (Equation 5.10)	tCH_4
21	=	Global warming potential of methane as carbon dioxide equivalent	tCO_2e/tCH_4

Equation 5.6. Project Methane Emissions from the Biogas Control System

$$PE_{CH_4,BCS} = \sum_i \left[\left[CH_{4,metered,i} \times \left(\left(\frac{1}{BCE} \right) - BDE_{i,weighted} \right) \right] + CH_{4,vent,i} \right]$$

Where,

			Units
$PE_{CH4,BCS}$	=	Methane emissions from the BCS, to be summed for each reporting period	tCH_4
$CH_{4,metered,i}$	=	Quantity of methane collected and metered in month *i*	tCH_4
BCE	=	Methane collection efficiency of the BCS. Project developers shall use the appropriate default value provided in Table B.4	fraction
$BDE_{i,weighted}$	=	Weighted average of all destruction devices used in month i	fraction
$CH_{4,vent,i}$	=	Quantity of methane that is vented to the atmosphere due to BCS venting events in month *i*, as quantified in Equation 5.7 below	tCH_4

$$CH_{4,metered,i} = F \times \frac{520}{T_b} \times \frac{P}{1} \times CH_{4,conc} \times 0.0423 \times 0.000454$$

Where,

			Units
$CH_{4,metered,i}$	=	Wuantity of methane collected and metered in month *i*[18]	tCH_4
F	=	Measured volumetric flow of biogas in month *i*	scf
T_b	=	Temperature of the biogas flow (°R = °F + 459.67)	°R
P	=	Pressure of the biogas flow	atm
$CH_{4,conc}$	=	Measured methane concentration of biogas for month *i*	fraction
0.0423	=	Density of methane gas (1 atm, 60°F)	lb CH_4/scf
0.000454	=	Conversion factor from lb to metric ton	

** The terms (520/T_b) and (P/1) should be omitted if the continuous flow meter internally corrects for temperature and pressure to 60°F and 1 atm.*

$$BDE_{i,weighted} = \frac{\sum_{DD}\left(BDE_{DD} \times F_{i,DD}\right)}{F_i}$$

Where,

			Units
$BDE_{i,weighted}$	=	Monthly weighted average of all destruction devices used in month *i*	fraction
BDE_{DD}	=	Default methane destruction efficiency of a particular destruction device 'DD'. See Appendix B for default destruction efficiencies[19]	fraction
$F_{i,DD}$	=	Monthly flow of biogas to a particular destruction device 'DD'	scf/month
F_i	=	Total monthly measured volumetric flow of biogas to all destruction devices	scf/month

[18] This value reflects directly measured biogas mass flow and methane concentration in the biogas to the combustion device.

[19] Project developers have the option to use either the default methane destruction efficiencies provided, or site specific methane destruction efficiencies, for each of the combustion devices used in the project. Site-specific values must be provided by an independent air emissions testing body that is accredited by a state or local agency, or the Stack Testing Accreditation Council (STAC). See Appendix B for more information. Where a state/region does not have an appropriate accreditation system or accredited service providers, the project developer may look to another state/region to find suitably qualified service providers.

Equation 5.7. Methane Emissions from Venting Events

$$CH_{4,vent,i} = \left(MGS_{BCS} + \left(F_{pw} \times t\right)\right) \times CH_{4,conc} \times 0.0423 \times 0.000454$$

Where,			Units
$CH_{4,vent,i}$	=	Quantity of methane that is vented to the atmosphere due to BCS venting events in month *i*	tCH_4
MGS_{BCS}	=	Maximum biogas storage of the BCS system[20]	scf
F_{pw}	=	Average total daily flow of biogas from the digester for the entire week prior to the venting event[20]	scf/day
t	=	Number of days of the month that biogas is venting uncontrolled from the BCS system (can be a fraction)	days
$CH_{4,conc}$	=	Measured methane concentration of biogas prior to the venting event	fraction
0.0423	=	Density of methane gas (1 atm, 60°F)	lb CH_4/scf
0.000454	=	Conversion factor from lb to metric ton	

Equation 5.8, along with Equation 5.9, shall be used to account for all treatment systems associated with the BCS effluent. The factor ETF_i shall be estimated by the project developer to determine what fraction of the VS in the effluent is sent to each treatment system, and is represented as a fraction (e.g. if 85% of the BCS effluent is sent to an effluent pond, then ETF_i for that system is equal to 0.85). Anaerobic effluent treatment systems are those which store liquid effluent in a lagoon, pond, or tank. This includes liquid storage systems that employ non-airtight covers (i.e. biogas is freely vented to the atmosphere) as long as the entire system is managed as a passive storage system, rather than an actively-managed treatment system (i.e. no heating, mixing, etc.).

Equation 5.8. Modeled Project Methane Emissions from Anaerobic Treatment of BCS Effluent

$$PE_{CH_4,ET,AS} = \sum_i \left(VS_{ET,i} \times B_{0,ET} \times days_{mo} \times 0.8 \times f \times 0.68 \times 0.001\right) \times \frac{rd_{mo}}{days_{mo}}$$

Where,			Units
$PE_{CH4,ET,AS}$	=	Monthly methane emissions from anaerobic effluent treatment systems	tCH_4
$VS_{ET,i}$	=	Volatile solids to anaerobic effluent treatment system *i* (see below)	kg/day
$B_{0,ET}$	=	Maximum methane producing capacity (of VS dry matter)[21]	m^3CH_4/kg VS
$days_{mo}$	=	Calendar days in the current month	days
0.8	=	Management and design practices factor[15]	fraction
f	=	The van't Hoff-Arrhenius factor, as calculated in Equation 5.3	
0.68	=	Density of methane (1 atm, 60°F)	kg/m^3
0.001	=	Conversion from kg to metric tons	t/kg
rd_{mo}	=	Reporting days in the current month	days

Equation 5.8 continued on next page

[20] If the BCS consists of multiple digester tanks or covered lagoons, the project only need quantify the maximum storage (MGS_{BCS}) and biogas flow (F_{pw}) of the component(s) of the BCS that experienced the venting event.

[21] The B_0 value for the project effluent pond is not differentiated by livestock category. Project developers shall use the B_0 value that corresponds with a weighted average of the operation's livestock categories that contribute manure to the BCS (weighted by the kg of VS contributed by each livestock category). Supporting laboratory data and documentation per Section 6.1 needs to be supplied to the verifier to justify an alternative value.

Equation 5.8. Continued

$$VS_{ET,i} = \left[\left(\sum_{L}(VS_L \times P_L \times MS_{L,BCS})\right) \times 0.3\right] \times ETF_i$$

Where, Units

$VS_{ET,i}$	=	Volatile solids to anaerobic effluent treatment system *i*	kg/day
VS_L	=	Volatile solids produced by livestock category 'L' on a dry matter basis. *Important* – refer to Box 5.1 for guidance on using appropriate units for VS_L values from Appendix B	kg/animal/day
P_L	=	Average population of livestock category *L* during the reporting period (based on monthly population data)	
$MS_{L,BCS}$	=	Fraction of manure from livestock category *L* that is managed in the BCS	fraction
0.3	=	Default value representing the amount of VS that exits the digester as a fraction of the VS entering the digester[22]	fraction
ETF_i	=	Fraction of the effluent that exits the digester and is sent to effluent treatment system *i*	fraction

If the effluent from the project digester is directed to a covered liquid effluent storage system, and the biogas from this storage system is not collected and destroyed, then the following scenarios apply:

1. If the effluent from this system is applied directly to land and biogas flow and methane concentration are monitored in accordance with Section 6, then $PE_{CH4,ET,AS}$ for this system shall be determined using Equation 5.6, assuming a BCE value of 0.95 and a BDE value of 0.

   For any periods where biogas flow and/or methane concentration data from this system are missing (and not replaceable through data substitution) or not in conformance with Section 6, Equation 5.8 shall be used to determine the quantity of project methane emissions from this system component.

2. If the effluent from the covered liquid effluent storage system is directed to another treatment system (i.e. not land-applied), then an additional calculation is required. The methane released from the covered liquid effluent system shall be quantified using the guidance in Scenario 1 above, but the additional methane released by the further treatment system must also be quantified. Equation 5.9 shall be used to calculate the methane released from the additional treatment system using the default assumptions that 30% of the $VS_{ET,i}$ from the effluent storage system enters the additional treatment system.

[22] Per ACM0010 (V2 Annex I).

Equation 5.9. Modeled Project Methane Emissions from Non-Anaerobic Treatment of BCS Effluent[23]

$$PE_{CH_4,ET,nAS} = \sum_{i}\left(VS_{ET,i} \times B_{0,ET} \times rd_{rp} \times 0.68 \times MCF_{ET,i} \times 0.001\right)$$

Where,

			Units
$PE_{CH4,ET,nAS}$	=	Project methane emissions from non-anaerobic effluent treatment systems during the reporting period	tCH_4
$VS_{ET,i}$	=	Volatile solids to non-anaerobic effluent treatment system *i* (see Equation 5.8)	kg/day
$B_{0,ET}$	=	Maximum methane producing capacity (of VS dry matter)[24]	m^3CH_4/kg
rd_{rp}	=	Number of reporting days in the current reporting period	days
0.68	=	Density of methane (1 atm, 60°F)	kg/m^3
$MCF_{ET,i}$	=	Methane conversion factor for effluent treatment system *i* (Table B.6)	fraction
0.001	=	Conversion factor from kg to metric tons	

Equation 5.10. Project Methane Emissions from *Non*-BCS Related Sources[25]

$$PE_{CH_4,other} = \sum_{L}\left(P_L \times VS_L \times B_{0,L} \times MCF_{non-BCS} \times rd_{rp} \times 0.68 \times 0.001\right)$$

Where,

			Units
$PE_{CH4,other}$	=	Methane from sources in the waste treatment and storage category other than the BCS and associated effluent treatment systems during the reporting period	tCH_4
P_L	=	Average population of livestock category *L* during the reporting period	
VS_L	=	Volatile solids produced by livestock category 'L' on a dry matter basis. Refer to Box 5.1 for guidance on using appropriate units for VS_L values from Appendix B	kg/ animal/ day
$B_{0,L}$	=	Maximum methane producing capacity of VS dry matter for manure for livestock category *L*, (Appendix B, Table B.3)	m^3 CH_4/kg
$MCF_{non-BCS}$	=	Management-weighted methane conversion factor for waste treatment and storage systems other than the BCS and associated effluent treatment systems	fraction
rd_{rp}	=	Number of reporting days in the current reporting period	days
0.68	=	Density of methane (1 atm, 60°F)	kg/m^3
0.001	=	Conversion factor from kg to metric tons	

$$MCF_{non-BCS} = \sum_{S}\left(MCF_S \times MS_{L,S}\right)$$

Where,

			Units
$MCF_{non-BCS}$	=	Management-weighted methane conversion factor for waste treatment and storage systems other than the BCS and associated effluent treatment systems	fraction
MCF_S	=	Methane conversion factor for system component *S* (Table B.9)	fraction
$MS_{L,S}$	=	Fraction of manure from livestock category *L* that is managed in non-BCS system component *S*	fraction

[23] Non-anaerobic effluent treatment systems are those which manage effluent in solid form, or those which manage liquid effluent in a way that would be considered aerobic (e.g. a pond with effective aeration equipment).

[24] The B_o value for the project effluent pond is not differentiated by livestock category. Project developers shall use the B_o value that corresponds with a weighted average of the operation's livestock categories that contribute manure to the BCS (weighted by the kg of VS contributed by each livestock category). Supporting laboratory data and documentation per Section 6.1, need to be supplied to the verifier to justify an alternative value.

[25] According to this protocol, non-BCS-related sources means manure management system components (system component 'S') other than the biogas control system and the BCS effluent treatment systems (if used).

5.4 Metered Methane Destruction Comparison

As described above, the Reserve requires all projects to compare the modeled methane emission reductions for the reporting period, as calculated in Equation 5.2 to Equation 5.4 and Equation 5.6 to Equation 5.9, with the actual metered amount of methane that is destroyed in the BCS over the same period. The lesser of the two values is to be used as the total methane emission reductions for the reporting period in question.

In order to calculate the metered methane reductions, the monthly quantity of biogas that is metered and destroyed by the BCS must be aggregated over the reporting period. In the event that a project developer is reporting reductions for a period of time that is less than a full year, the total modeled methane emission reductions would be aggregated over this time period and compared with the metered methane that is destroyed in the BCS over the same period of time. Similarly, projects whose reporting periods begin or end with incomplete calendar months shall only quantify the baseline and project emissions for the portion of the month that is included within the reporting period. For example, if a project is reporting and verifying only 6 months of data (e.g. July to December), then the modeled emission reductions over this 6 month period would be compared to the total metered biogas destroyed over the same six month period, and the lesser of the two values would be used as the total methane emission reduction quantity for this six month period. See Equation 5.1 for calculation guidance.

Equation 5.11 below details the metered methane destruction calculation.

Equation 5.11. Metered Methane Destruction

$$\boldsymbol{BE_{metered} = \sum_{i}\left(CH_{4,metered,i} \times BDE_{i,weighted}\right) \times 21}$$

Where,			Units
$BE_{metered}$	=	Aggregated quantity of methane collected and destroyed during the reporting period	tCO_2e
$CH_{4,metered,i}$	=	Quantity of methane collected and metered in month $_i$. See Equation 5.6 for calculation guidance	tCH_4/month
$BDE_{i,weighted}$	=	Weighted average of all destruction devices used in month *i*.[26] See Equation 5.6 for calculation guidance	fraction
21	=	Global warming potential of methane as carbon dioxide equivalent	tCO_2e/tCH_4

5.5 Calculating Baseline and Project Carbon Dioxide Emissions

Sources of carbon dioxide emissions associated with a project may include electricity use by pumps and equipment, fossil fuel generators used to power pumping systems or milking parlor equipment, tractors that operate in barns or free-stalls, on-site manure hauling trucks, or vehicles that transport manure off-site. Per Table 4.1, the carbon dioxide emissions from any additional equipment, vehicles, or fuel use that is required by the project beyond what is required in the baseline shall be accounted for. In practice, project developers shall account for the emissions from any new electric- or fuel-powered equipment or vehicles purchased and

[26] Project developers have the option to use either the default methane destruction efficiencies provided, or site specific methane destruction efficiencies, for each of the combustion devices used in the project. Site-specific values must be provided by an independent air emissions testing body that is accredited by a state or local agency, or the Stack Testing Accreditation Council (STAC). See Appendix B for more information.

installed/operated specifically for the purpose of implementing the project, as well as any additional fuel used by old or new vehicles to collect or transport waste.

Project developers may either use Equation 5.12 below to calculate the net increase in carbon dioxide emissions, or, if they can demonstrate during verification that project carbon dioxide emissions are estimated to be equal to or less than 5% of the total baseline emissions, then the project developer may estimate baseline and project carbon dioxide emissions. If an estimation method is used, verifiers shall confirm based on professional judgment that project carbon dioxide emissions are equal to or less than 5% of the total baseline emissions based on documentation and the estimation methodology provided by the project developer. If emissions cannot be confirmed to be below 5%, then Equation 5.12 shall be used. Regardless of the method used, all estimates or calculations of anthropogenic carbon dioxide emissions within the GHG Assessment Boundary must be verified and included in emission reduction calculations.[27]

If calculations or estimates indicate that the project results in a net decrease in carbon dioxide emissions from grid-delivered electricity, mobile and stationary sources, then for quantification purposes the net increase in these emissions must be specified as zero (i.e. $CO_{2,net} = 0$ in Equation 5.12).

Carbon dioxide emissions from the combustion of biogas are considered biogenic emissions and are excluded from the GHG Assessment Boundary.

Equation 5.12 below calculates the net increase in anthropogenic carbon dioxide emissions resulting from the project activity.

[27] This is consistent with guidance in WRI's GHG Project Protocol regarding the treatment of significant secondary effects.

Equation 5.12. Increased Carbon Dioxide Emissions

$$CO_{2,net} = BE_{CO_2,MSC} - PE_{CO_2,MSC}$$

Where,			Units
$CO_{2,net}$	=	Net increase in anthropogenic CO_2 emissions from electricity consumption and mobile and stationary combustion sources resulting from project activity during the reporting period. If result is <0, use a value of 0	tCO_2
$BE_{CO2,MSC}$	=	Total baseline CO_2 emissions from electricity consumption and mobile and stationary combustion sources during the reporting period (see equation below)	tCO_2
$PE_{CO2,MSC}$	=	Total project CO_2 emissions from electricity consumption and mobile and stationary combustion sources during the reporting period (see equation below)	tCO_2

All CO_2 emissions associated with electricity consumption and stationary and mobile combustion are calculated using the equation:

$$CO_{2,MSC} = \left(\sum_c QE_c \times EF_{CO_2,e}\right) + \left[\left(\sum_c QF_c \times EF_{CO_2,f}\right) \times 0.001\right]$$

Where,			Units
$CO_{2,MSC}$	=	Anthropogenic CO_2 emissions from electricity consumption and mobile and stationary combustion sources	tCO_2
QE_c	=	Quantity of grid-connected electricity consumed for each emissions source 'c'[28] during the reporting period	MWh
$EF_{CO2,e}$	=	CO_2 emission factor for electricity used[29]	tCO_2/MWh
QF_c	=	Quantity of fuel consumed for each mobile and stationary emission source 'c' during the reporting period	MMBtu or gallons
$EF_{CO2,f}$	=	Fuel-specific emission factor *f* from Appendix B	kg CO_2/MMBtu or kg CO_2/gallon
0.001	=	Conversion factor from kg to metric tons	

[28] Emissions from electricity generated by the BCS and consumed onsite, do not need to be reported, as the resulting CO_2 emissions are considered biogenic, CH_4 is captured by the BDE calculation and N_2O emissions are excluded as negligible.
[29] Refer to the version of the U.S. EPA eGRID most closely corresponding to the time period during which the electricity was used. Projects shall use the annual total output emission rates for the subregion where the project is located, not the annual non-baseload output emission rates. The eGRID tables are available from the U.S. EPA website: http://www.epa.gov/cleanenergy/energy-resources/egrid/index.html

6 Project Monitoring

The Reserve requires a Monitoring Plan to be established for all monitoring and reporting activities associated with the project. The Monitoring Plan will serve as the basis for verification bodies to confirm that the monitoring and reporting requirements in this section and Section 7 have been and will continue to be met, and that consistent, rigorous monitoring and record-keeping is ongoing at the project site. The Monitoring Plan must cover all aspects of monitoring and reporting contained in this protocol and must specify how data for all relevant parameters in Table 6.1 (below) will be collected and recorded.

At a minimum the Monitoring Plan shall stipulate the frequency of data acquisition; a record keeping plan (see Section 7.2 for minimum record keeping requirements); the frequency of instrument field check and calibration activities; and the role of individuals performing each specific monitoring activity, as well as QA/QC provisions to ensure that data acquisition and meter calibration are carried out consistently and with precision. The Monitoring Plan shall also contain a detailed diagram of the BCS, including the placement of all meters and equipment that affect SSRs within the GHG Assessment Boundary (see Figure 4.1 and Appendix F).

For a project's second crediting period, the Monitoring Plan must also include procedures that the project developer will follow to ascertain and demonstrate that the project at all times passes the Legal Requirement Test (Section 3.5.2).

Project developers are responsible for monitoring the performance of the project and operating each component of the biogas collection and destruction system in a manner consistent with the manufacturer's recommendations.

6.1 Site-Specific Determination of Maximum Methane Potential (B_0)[30]

The determination of a site-specific value for maximum methane potential (B_0) is optional for manure from dairy facilities. Swine facilities must use the default values. For projects that choose this option for the quantification of emission reductions related to one or more manure streams being digested in the project's BCS, or the BCS effluent, the following criteria must be met in order to ensure accuracy and consistency of the site-specific B_0 values:

1. Manure samples for each eligible livestock category must be sampled prior to mixing with manure from other animal categories or any other waste streams. These samples shall be taken from the manure collection system, rather than from an individual animal.
   a. Scrape systems: Samples shall be collected from the freshly scraped manure.
   b. Flush systems: Samples shall be collected at the point that the flushed manure leaves the barn. Additional samples must be collected of the flush water prior to mixing with manure.
   c. BCS effluent: Samples shall be collected after the effluent has exited the digester and prior to any further treatment.

2. Sampling events shall occur during the time period between August and October, inclusive.
   a. Manure samples: For each eligible animal category, there shall be one single-day sampling event. A total of at least six samples of at least one half liter each must

[30] Background information on the development of this section can be found in Appendix E.

be taken during the event. Samples shall be taken one to three hours apart, and all samples of the same type shall be combined (i.e. dairy cow manure samples in one container). The composite sample shall be delivered to the testing laboratory as soon as possible following the collection of the final sample.[31]

b. Flush water samples: If the farm utilizes a flush system for manure collection, the flush water must be sampled prior to mixing with manure. Two samples of at least one liter shall be collected, one to three hours apart, during the manure sampling event. These samples shall be combined into one container and delivered to the testing laboratory as soon as possible.
c. Effluent samples: Two samples of at least one liter shall be collected, one to three hours apart, during the manure sampling event. These samples shall be combined into one container and delivered to the testing laboratory as soon as possible.[32]

3. All samples must be analyzed using a Biochemical Methane Potential (BMP) Assay procedure at an independent, third-party laboratory that is familiar and experienced with this test and ISO 11734.[33] The laboratory must be able to document at least three years of experience with the BMP assay, and must have procedures in place to maintain a consistent inoculum. The laboratory must maintain and follow a standard operating procedure that outlines the process used in undertaking BMP analysis at that laboratory, and which can be made available to the verifier upon request.

4. At least six test runs shall be conducted using material from the mixed manure sample (i.e. split the sample into two and test each in triplicate). Tests shall report the weight of VS for the sample (as kg of dry matter) as well as the volume of methane produced, in order to determine the maximum methane potential as m^3 CH_4/kg VS. If applicable, the flush water sample and effluent sample shall each be used for one test run in triplicate. The laboratory shall conduct an assay on the seed inoculum itself in order to control for its contribution to the methane potential of the manure samples. The laboratory shall also conduct a control assay with a substrate of known methane potential (such as glucose or cellulose) to verify correct procedures were followed and that the inoculum was viable. If the control assay differs from its established expected value by greater than 15%, all results from that batch of assays shall be discarded. Measurement of gas flow shall be corrected to standard temperature and pressure (60°F and 1 atm). Devices used to measure gas flow and methane content shall be properly installed and calibrated, such that they can provide results within +/- 5% accuracy.

5. After the manure sample has been analyzed, there should be at least six estimates for the methane potential. The site specific value for B_0 shall equal the 90% lower confidence limit of all assay results. For flush systems, the mean methane potential of the flush water results must be subtracted from the calculated methane potential of the flushed manure sample. For BCS effluent, the mean methane potential of the test results

[31] Note, while there is no prescribed timeline regarding how quickly samples must be delivered to a laboratory, the longer a sample is retained before testing, the lower the methane generating potential will be. This loss can be mitigated by storing and transporting samples at temperatures below 5°C.
[32] *Ibid*.
[33] For more information on BMP Assay analysis and procedures, see: Moody et al. "Use of Biochemical Methane Potential (BMP) Assays for Predicting and Enhancing Anaerobic Digester Performance." (2009) http://sa.pfos.hr/sa2009/radovi/pdf/Radovi/r10-009.pdf

shall be used for the quantification. Additional sampling and assays may be carried out, and will reduce uncertainty and result in a final value that is closer to the mean.

Site-specific B_0 values determined using this procedure shall be valid for the reporting period during which the sampling occurred. Projects may elect to determine a site-specific B_0 value for only a subset of the eligible manure streams and utilize default values for the remainder. The verifier must confirm that sampling procedures conform to this section and that the personnel responsible for the sampling are trained and competent.

6.2 Biogas Control System Monitoring Requirements

The methane capture and control system must be monitored with measurement equipment that directly meters:

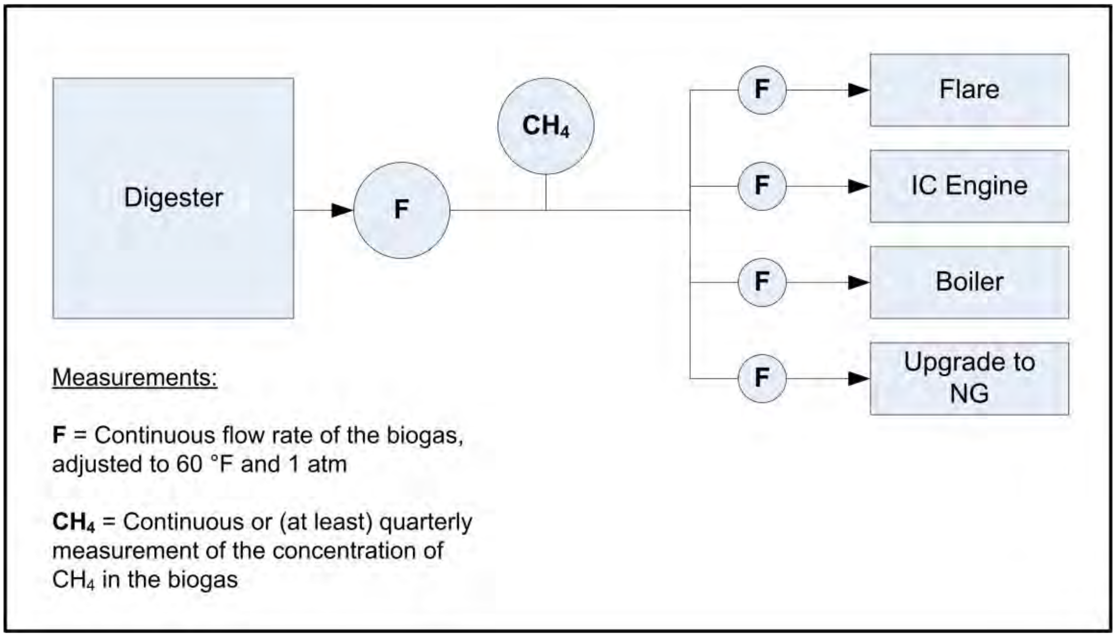
- The total flow of biogas, measured continuously and recorded every 15 minutes or totalized and recorded at least daily, adjusted for temperature and pressure, prior to delivery to the destruction device(s).
- The flow of biogas delivered to each destruction device (except as described below), measured continuously and recorded at least every 15 minutes or totalized and recorded at least daily, adjusted for temperature and pressure.
- The fraction of methane in the biogas, measured with a continuous analyzer or, alternatively, with at least quarterly measurements.
- The operational status of each destruction device (except as described below), measured and recorded at least hourly.

Flow data must be corrected for temperature and pressure at 60°F and 1 atm, either internally or by following the guidance in Equation 5.6.

A single flow meter may be used to monitor the flow of gas to multiple destruction devices under certain conditions. If all destruction devices are of identical methane destruction efficiency (as described in Table B.7) and verified to be operational (i.e. there is recorded evidence of destruction), no additional steps are necessary for project registration. One example of this scenario would be a single meter used for a bank of multiple, identical engines that are in constant operation. If the destruction devices are not of identical efficiency, then the destruction efficiency of the least efficient device shall be applied to the flow data for this meter.
If there are any periods where the operational data show that one or more devices were not destroying methane, these periods are eligible for crediting, provided that the verifier can confirm all of the following conditions are met:

a. The destruction efficiency of the least efficient destruction device in operation shall be used as the destruction efficiency for all destruction devices monitored by this meter; and
b. All devices are either equipped with valves on the input gas line that close automatically if the device becomes non-operational (requiring no manual intervention), or designed in such a manner that it is physically impossible for gas to pass through while the device is non-operational; and
c. For any period where one or more destruction device(s) within this arrangement is not operational, it must be documented that the remaining operational devices have the capacity to destroy the maximum gas flow recorded during the period. For devices other than flares, it must be shown that the output corresponds to the flow of gas.

Figure 6.1 represents the suggested arrangement of the biogas flow meters and methane concentration metering equipment.



Note: The number of flow meters must be sufficient to track the total flow as well as the flow to each combustion device. The above example includes one more flow meter than would be necessary to achieve this objective.

Figure 6.1. Suggested Arrangement of Biogas Metering Equipment

Operational activity of the destruction devices shall be monitored and documented at least hourly to ensure actual methane destruction.

If for any reason the destruction device or the operational monitoring equipment (for example, the thermocouple on the flare) is inoperable, then all metered biogas going to the particular device shall be assumed to be released to atmosphere during the period of inoperability. In other words, during the period of inoperability, the destruction efficiency of the device must be assumed to be zero. In Equation 5.10, the monthly destruction efficiency (BDE) value shall be adjusted accordingly. See Box 6.1 below for an example BDE adjustment.

Box 6.1. Example BDE Adjustment

As an example, consider a situation where the primary destruction device is an open flare with a BDE of 96%, and it is found to be inoperable for a period of 5 days of a 30 day month. Assume that the total flow of biogas to the flare for the month is 3,000,000 scf, and that the total flow recorded for the 5 day period of inoperability is 500,000 scf. In this case the monthly BDE would be adjusted as follows:

$$BDE = \frac{[(0.96 \times 2{,}500{,}000) + (0.0 \times 500{,}000)]}{3{,}000{,}000} = 80\%$$

6.3 Biogas Measurement Instrument QA/QC

All gas flow meters[34] and continuous methane analyzers must be:

- In calibration (accurate to +/- 5% of the true value being measured) at time of installation. Calibration accuracy can be demonstrated through either a recent field check (as installed) or calibration by the manufacturer or a certified calibration service.
- Maintained per manufacturer's guidance, as well as cleaned and inspected on a quarterly basis, with the activities performed and as found/as left condition of the equipment documented.
- Field checked for calibration accuracy by an appropriately trained individual or a third-party technician with the percent drift documented, using either a portable instrument (such as a pitot tube)[35] or manufacturer specified guidance, at the end of but no more than 60 days prior to or after the end date of the reporting period.[36]
- Calibrated by the manufacturer or a certified calibration service per manufacturer's guidance or every 5 years, whichever is more frequent. Meters shall be calibrated to the range of conditions expected on site (e.g. pipe diameter, flow rate, temperature, pressure, gas composition) and as found/as left condition of the equipment documented.

If a stationary meter that was in use for 60 days or more is removed and not reinstalled during a reporting period, that meter shall either be field-checked for calibration accuracy prior to removal or calibrated (with percent drift documented) by the manufacturer or a certified calibration service prior to quantification of emission reductions for that reporting period.

If the field check on a piece of equipment reveals accuracy outside of a +/- 5% threshold, calibration by the manufacturer or a certified service provider is required for that piece of equipment, with as found/as left condition of the equipment documented.

For the interval between the last successful field check and any calibration event confirming accuracy below the +/- 5% threshold, all data from that meter or analyzer must be scaled according to the following procedure. These adjustments must be made for the entire period from the last successful field check until such time as the meter is properly calibrated and re-installed.

- For calibrations that indicate the flow meter was outside the +/- 5% accuracy threshold, the project developer shall estimate total emission reductions using i) the metered values without correction, and ii) the metered values adjusted based on the greatest calibration drift recorded at the time of calibration. The lower of the two emission reduction estimates shall be reported as the scaled emission reduction estimate.

[34] Field checks and calibrations of flow meters shall assess the volumetric output of the flow meter in SCF at 1 atm pressure and 60°F temperature.
[35] It is recommended that a professional third party calibration service be hired to perform flow meter field checks if using pitot tubes or other portable instruments, as these types of devices require professional training in order to achieve accurate readings.
[36] Instead of performing field checks, the project developer may instead have equipment calibrated by the manufacturer or a certified calibration service per manufacturer's guidance, at the end of but no more than 60 days prior to or after the end date of the reporting period to meet this requirement.

For example, if a project conducts field checks quarterly during a year-long verification period, then only three months of data will be subject at any one time to the penalties above. However, if the project developer feels confident that the meter does not require field checks or calibration on a greater than annual basis, then failed events will accordingly require the penalty to be applied to the entire year's data. Further, frequent calibration may minimize the total accrued drift (by zeroing out any error identified), and result in smaller overall deductions.

If a portable instrument is used (such as a handheld methane analyzer), the portable instrument shall be calibrated at least annually – or per the manufacturer's guidance, whichever is more frequent – by the manufacturer or at an ISO 17025 accredited laboratory. Portable methane analyzers shall be calibrated to a known reference gas prior to each use.

6.3.1 Missing Data

In situations where the flow rate or methane concentration monitoring equipment is missing data, the project developer shall apply the data substitution methodology provided in Appendix D. This methodology may also be used for periods where the project developer can show that the data are available but known to be corrupted (and where this corruption can be verified with reasonable assurance). If for any reason the monitoring equipment on any given destruction device is inoperable (for example, the thermocouple on the flare), then the destruction efficiency of that device must be assumed to be zero. For periods when it is not possible to use data substitution to fill data gaps, no emission reductions may be claimed. The methane flow volume for these days shall be zero, and the number of reporting days for that month shall be reduced to exclude the days of missing data (see Box 5.2).

During any period where the project is not claiming emission reduction credits and is not classifying the period as a venting event, the project developer must be able to demonstrate that project emissions were not greater than baseline emissions.

6.4 Monitoring Parameters

Provisions for monitoring other variables to calculate baseline and project emissions are provided in Table 6.1. The parameters are organized by general project factors then by the calculation methods.

Table 6.1. Project Monitoring Parameters

Equation Reference	Parameter	Description	Data Unit	Calculated (c) Measured (m) Reference (r) Operating Records (o)	Measurement Frequency	Comment
	Regulations	Project developer attestation to compliance with regulatory requirements relating to the manure digester project	All applicable regulations	n/a	Every verification period	Information used to demonstrate compliance with associated regulations and rules, e.g. criteria pollutant and effluent discharge limits.
	L	Type of livestock categories on the farm	Livestock categories	o	Monthly	See Appendix B, Table B.2.
Equation 5.1	$ER_{modeled}$	Avoided methane emissions associated with the project during the reporting period	tCO_2e	c	Every reporting period	Quantified using a modeled baseline scenario.
Equation 5.1	$BE_{modeled}$	Modeled baseline emissions during the reporting period	tCO_2e	c	Every reporting period	Quantified using a modeled baseline scenario.
Equation 5.1 Equation 5.5	PE_{CH4}	Total project methane emissions during the reporting period	tCO_2e	c	Every reporting period	Quantified using a modeled project scenario and metered methane destruction data.
Equation 5.1 Equation 5.12	$CO_{2,net}$	Net increase in anthropogenic CO_2 emissions from electricity and mobile/stationary combustion	tCO_2e	c	Every reporting period	
Equation 5.1	$ER_{metered}$	Avoided methane emissions associated with the project during the reporting period	tCO_2e	c	Every reporting period	Quantified using metered methane destruction data.
Equation 5.1 Equation 5.11	$BE_{metered}$	Aggregated quantity of methane collected and destroyed during the reporting period	tCO_2e	c	Every reporting period	Quantified using metered methane destruction data.

Equation Reference	Parameter	Description	Data Unit	Calculated (c) Measured (m) Reference (r) Operating Records (o)	Measurement Frequency	Comment
Equation 5.2	$BE_{CH4,AS,L}$	Total baseline methane emissions from anaerobic storage/treatment systems by livestock category, aggregated for reporting period	tCO_2e	c	Monthly	
Equation 5.2 Equation 5.4	$BE_{CH4,nAS,L}$	Total baseline methane emissions for the reporting period from non-anaerobic storage/treatment systems by livestock category	tCO_2e	c	Every reporting period	
Equation 5.3	$VS_{deg,AS,L}$	Monthly volatile solids degraded in each anaerobic storage system *AS*, for each livestock category *L*	kg	c, o	Monthly	Calculated value from operating records. Recommend Reserve Livestock Calculation Tool for all calculations.
Equation 5.3 Equation 5.4 Equation 5.10	$B_{0,L}$	Maximum methane producing capacity for manure by livestock category	(m^3 CH_4/ kg VS)	r	Every reporting period	See Appendix B, Table B.3.
Equation 5.3 Equation 5.8	$days_{mo}$	Calendar days per month	days	r	Monthly	See Box 5.2.
Equation 5.3 Equation 5.8	rd_{mo}	Reporting days during the current month	days	o	Monthly	See Box 5.2.
Equation 5.3	$VS_{avail,AS,L}$	Monthly volatile solids available for degradation in each anaerobic storage system, for each livestock category	kg	c, o	Monthly	Calculated value from operating records. Recommend Reserve Livestock Calculation Tool for all calculations.
Equation 5.3 Equation 5.8	*f*	van't Hoff-Arrhenius factor	n/a	c	Monthly	The proportion of volatile solids that are biologically available for conversion to methane based on the monthly temperature of the system. Recommend Reserve Livestock Calculation Tool for all calculations.
Equation 5.3 Equation 5.4 Equation 5.8 Equation 5.10	VS_L	Daily volatile solid production for each livestock category	(kg/animal/ day)	r, c	Every reporting period	Appendix B, Table B.3 and Table B.5a-d; see Box 5.1 for guidance on converting units from (kg/day/1000kg) to (kg/animal/day).

Equation Reference	Parameter	Description	Data Unit	Calculated (c) Measured (m) Reference (r) Operating Records (o)	Measurement Frequency	Comment
Equation 5.3 Equation 5.4 Equation 5.8 Equation 5.10	P_L	Average number of animals for each livestock category	population (# head)	o	Monthly	
Equation 5.3	$MS_{AS,L}$	Fraction of manure from each livestock category managed in the anaerobic waste handling system	%	o	Every reporting period	Reflects the percent of waste handled by the system components *S* pre-project. Each system component must have an MS value per livestock category. Within each livestock category, the sum of MS values (for all treatment/storage systems) equals 100%. See Appendix B, Table B.1.
Equation 5.3	$VS_{avail-1,AS}$	Previous month's volatile solids available for degradation in anaerobic system	kg	c	Monthly	
Equation 5.3	$VS_{deg-1,AS}$	Previous month's volatile solids degraded by anaerobic system	kg	c	Monthly	
Equation 5.3	E	Activation energy constant	cal/mol	r		15,175 cal/mol
Equation 5.3	T_{mo}	Average monthly temperature at location of the operation	°C	m/o	Monthly	Used for van't Hoff calculation and for choosing appropriate MCF value.
Equation 5.3	T_{ref}	Reference temperature	K	r		303.16 Kelvins
Equation 5.3	R	Ideal gas constant	cal/Kmol	r		1.987 cal/Kmol
Equation 5.4	$MS_{L,nAS}$	Fraction of manure from each livestock category *L* managed in the non-anaerobic waste handling system	%	o	Every reporting period	Reflects the percent of waste handled by the system components *S* pre-project. Each system component must have an MS value per livestock category. Within each livestock category, the sum of MS values (for all treatment/storage systems) equals 100%. See Appendix B, Table B.1.
Equation 5.4	$days_{rp}$	Number of days in the reporting period	days	o	Every reporting period	See Box 5.2.
Equation 5.4	MCF_{nAS}	Methane conversion factor for non-anaerobic storage/treatment system	%	r	Every reporting period	From Appendix B. Differentiate by livestock category.

Equation Reference	Parameter	Description	Data Unit	Calculated (c) Measured (m) Reference (r) Operating Records (o)	Measurement Frequency	Comment
Equation 5.4 Equation 5.9 Equation 5.10	rd_{rp}	Reporting days during the reporting period	days		Every reporting period	See Box 5.2.
Equation 5.5 Equation 5.6	$PE_{CH4,BCS}$	Methane emissions from the BCS	tCH_4	m, c	Every reporting period	Calculated for each month and summed for the reporting period.
Equation 5.5 Equation 5.8	$PE_{CH4,ET,AS}$	Methane emissions from the BCS effluent anaerobic treatment systems	tCH_4	m, c	Every reporting period	Calculated for each month and summed for the reporting period.
Equation 5.5 Equation 5.9	$PE_{CH4,ET,nAS}$	Methane emissions from the BCS effluent non-anaerobic treatment systems	tCH_4	m, c	Every reporting period	Calculated for the reporting period.
Equation 5.5 Equation 5.10	$PE_{CH4,other}$	Methane emissions from sources in the waste treatment and storage category other than the BCS and associated effluent treatment systems	tCH_4	m, c	Every reporting period	Calculated for the reporting period.
Equation 5.6 Equation 5.11	$CH_{4,metered,i}$	Metered amount of methane collected and destroyed by the BCS in month *i*	tCH_4	m, c	Monthly calculation from continuous data	Calculated from biogas flow and methane fraction meter readings (See *F* and $CH_{4,conc}$ parameters below).
Equation 5.6	BCE	Biogas capture efficiency of the anaerobic digester, accounts for fugitive emissions	fraction	r	Every reporting period	Use default value from Table B.4.
Equation 5.6 Equation 5.11	$BDE_{i,weighted}$	Methane destruction efficiency of destruction device(s)	fraction	r, c	Monthly	Actual efficiency of the system to destroy captured methane gas – accounts for different destruction devices.
Equation 5.6 Equation 5.7	$CH_{4,vent,i}$	Quantity of methane that is vented to the atmosphere due to BCS venting events	scf	c	Monthly	Calculated from average total flow of biogas from the digester and the number of days biogas is venting.
Equation 5.6	F	Volume of biogas from digester to destruction devices	scf	m	Continuously, aggregated monthly	Measured continuously from flow meter and recorded every 15 minutes or totalized and recorded at least once daily. Data to be aggregated monthly.

Equation Reference	Parameter	Description	Data Unit	Calculated (c) Measured (m) Reference (r) Operating Records (o)	Measurement Frequency	Comment
Equation 5.6	T_b	Temperature of the biogas	°R (Rankine)	m	Continuously, averaged monthly	Measured to normalize volume flow of biogas to STP. No separate monitoring of temperature is necessary when using flow meters that automatically measure temperature and pressure, expressing biogas volumes in normalized cubic feet.
Equation 5.6	P	Pressure of the biogas	atm	m	Continuously, averaged monthly	Measured to normalize volume flow of biogas to STP. No separate monitoring of pressure is necessary when using flow meters that automatically measure temperature and pressure, expressing biogas volumes in normalized cubic feet.
Equation 5.6 Equation 5.7	$CH_{4,conc}$	Methane concentration of biogas	fraction	m	At least quarterly	Samples to be taken at least quarterly. See Section 6.2 for metering guidance.
Equation 5.6	BDE_{DD}	Default methane destruction efficiency of a particular destruction device	%	r	Monthly	See Appendix B for default destruction efficiencies by device.
Equation 5.6	$F_{i,DD}$	Flow of biogas to a particular destruction device	scf	m	Monthly	See Section 6.2 for metering guidance.
Equation 5.6	F_i	Total volumetric flow of biogas to all destruction devices	scf	m	Monthly	See Section 6.2 for metering guidance.
Equation 5.7	MGS_{BCS}	Maximum biogas storage of the BCS system	scf	r	Every reporting period	Obtained from digester system design plans. Necessary to quantify the release of methane to the atmosphere due to an uncontrolled venting event.
Equation 5.7	F_{pw}	Average total daily flow of biogas from the digester for the entire week prior to the uncontrolled venting event	scf/day	m	Weekly	Average flow of biogas can be determined from the daily records from the previous week.
Equation 5.7	t	Number of days of the month that biogas is venting uncontrolled from the BCS system	days	m, o	Monthly	

Equation Reference	Parameter	Description	Data Unit	Calculated (c) Measured (m) Reference (r) Operating Records (o)	Measurement Frequency	Comment
Equation 5.8 Equation 5.9	$VS_{ET,i}$	Volatile solids to effluent treatment system *i*	kg/day	r, c	Every reporting period	If project uses effluent pond, equals 30% of the average daily VS entering the digester.
Equation 5.8 Equation 5.9	$B_{0,ET}$	Maximum methane producing capacity of VS dry matter	(m^3 CH_4/ kg VS)	c	Every reporting period	An average of the $B_{0,EF}$ value of the operation's livestock categories that contributes manure to the BCS.
Equation 5.8	$MS_{L,BCS}$	Fraction of manure from each livestock category managed in the BCS	fraction	o	Every reporting period	Used to determine the total VS entering the digester. The fraction should be tracked in operational records.
Equation 5.8	ETF_i	Fraction of the effluent that exits the digester that is sent to effluent treatment system		o, r	Every reporting period	Used to determine the amount of VS for each effluent treatment system. The percentage should be tracked in operational records, or the project developer may provide a technical reference to support this fraction.
Equation 5.9	$MCF_{ET,i}$	Methane conversion factor for effluent treatment system	%	r	Every reporting period	See Appendix B. Project developers should use the *liquid slurry* MCF value.
Equation 5.10	$MCF_{non\text{-}BCS}$	Management-weighted methane conversion factor for waste treatment and storage systems other than the BCS and associated effluent treatment systems	%	r	Every reporting period	Referenced from Appendix B.
Equation 5.10	MCF_S	Methane conversion factor for system component		r		See Table B.9.
Equation 5.10	$MS_{L,S}$	Manure from each livestock category managed in the baseline waste handling system	fraction	o	Every reporting period	Fraction of waste handled by the system component *S* pre-project. Each system component must have an MS value per livestock category. Within each livestock category, the sum of MS values (for all treatment/storage systems) equals 1. See Appendix B, Table B.1.
Equation 5.12	$BE_{CO2,MSC}$	Total baseline CO_2 emissions from electricity and mobile/stationary combustion during reporting period	tCO_2	c	Every reporting period	

Equation Reference	Parameter	Description	Data Unit	Calculated (c) Measured (m) Reference (r) Operating Records (o)	Measurement Frequency	Comment
Equation 5.12	$PE_{CO2,MSC}$	Total project CO_2 emissions from electricity and mobile/stationary combustion during reporting period	tCO_2	c	Every reporting period	
Equation 5.12	$CO_{2,MSC}$	Anthropogenic CO_2 emissions from electricity and mobile/stationary combustion	tCO_2	c	Every reporting period	
Equation 5.12	QE_c	Quantity of electricity consumed	MWh	o, c	Every reporting period	Electricity used by project for manure collection, transport, treatment/storage, and disposal.
Equation 5.12	$EF_{CO2,e}$	Emission factor for electricity used by project	tCO_2/MWh	r	Every reporting period	See Appendix B. If biogas produced from digester is used to generate electricity consumed, the EF is zero.
Equation 5.12	QF_c	Quantity of fuel used for mobile/stationary combustion sources	MMBtu or gallons	o, c	Every reporting period	Fuel used by project for manure collection, transport, treatment/storage, and disposal, and stationary combustion sources including supplemental fossil fuels used in combustion device.
Equation 5.12	$EF_{CO2,f}$	Fuel-specific emission factor for mobile/stationary combustion sources	kg CO_2/ MMBtu or kg CO_2/ gallon	r	Every reporting period	Refer to EPA eGRID for emission factors. If biogas produced from digester is used as an energy source, the EF is zero.

7 Reporting Parameters

This section provides requirements and guidance on reporting rules and procedures. A priority of the Reserve is to facilitate consistent and transparent information disclosure among project developers. Project developers must submit either a project monitoring report or a verified emission reduction report to the Reserve annually at minimum, depending on the verification option selected by the project developer.

7.1 Project Documentation

Project developers must provide the following documentation to the Reserve in order to register a livestock project:

- Project Submittal form
- Project diagram from Monitoring Plan – see Appendix F (not public)
- Completed Reserve Livestock Calculation Tool, if used (not public)
- Signed Attestation of Title form
- Signed Attestation of Voluntary Implementation form[37]
- Signed Attestation of Regulatory Compliance form
- Verification Report
- Verification Statement

Project developers must provide the following documentation each verification period in order for the Reserve to issue CRTs for quantified GHG reductions:

- Verification Report
- Verification Statement
- Project diagram from Monitoring Plan – see Appendix F (not public)
- Completed Reserve Livestock Calculation Tool, if used (not public)
- Signed Attestation of Title form
- Signed Attestation of Regulatory Compliance form
- Signed Attestation of Voluntary Implementation form (second crediting period only)

Unless otherwise specified, the above project documentation will be available to the public via the Reserve's online registry. Further disclosure and other documentation may be made available on a voluntary basis through the Reserve. Project forms can be found athttp://www.climateactionreserve.org/how/program/documents/. .

7.2 Record Keeping

For purposes of independent verification and historical documentation, project developers are required to keep all information outlined in this protocol for a period of 10 years after the information is generated or 7 years after the last verification. This information will not be publicly available, but may be requested by the verifier or the Reserve.

[37] A project developer only needs to attest that the project passes the Legal Requirement Test during its first verification period of a crediting period. Meeting the Legal Requirement Test is not required for the remainder of the first crediting period after initial verification.

System Information:

- All data inputs for the calculation of the baseline emissions and project emission reductions
- CO_2e annual tonnage calculations (including copies of the Reserve Livestock Calculation Tool, if used)
- Relevant sections of the BCS operating permits
- Executed Attestation of Title forms, Attestation of Regulatory Compliance forms, and Attestation of Voluntary Implementation form
- BCS information (installation dates, equipment list, etc.)
- Biogas flow meter information (model number, serial number, manufacturer's calibration procedures)
- Cleaning and inspection records for all biogas meters
- Field check results for all biogas meters
- Calibration results for all biogas meters
- Methane monitor information (model number, serial number, calibration procedures)
- Biogas flow data (for each flow meter)
- Biogas temperature and pressure readings (only if flow meter does not correct for temperature and pressure automatically)
- Methane concentration monitoring data
- Destruction device monitoring data (for each destruction device)
- Destruction device, methane monitor and biogas flow monitor information (model numbers, serial numbers, calibration procedures)
- Initial and annual verification records and results
- All maintenance records relevant to the BCS, monitoring equipment, and destruction devices

If using a calibrated portable gas analyzer for CH_4 content measurement:

- Date, time, and location of methane measurement
- Methane content of biogas (% by volume) for each measurement
- Methane measurement instrument type and serial number
- Date, time, and results of instrument calibration
- Corrective measures taken if instrument does not meet performance specifications

7.3 Reporting and Verification Cycle

To provide flexibility and help manage verification costs associated with livestock projects, there are three verification options to choose from after a project's initial verification and registration. Regardless of the option selected, project developers must report GHG reductions resulting from project activities during each reporting period. A "reporting period" is a period of time over which a project developer quantifies and reports GHG reductions to the Reserve. Under this protocol, the reporting period cannot exceed 12 months. A "verification period" is the period of time over which GHG reductions are verified. Under this protocol, a verification period may cover multiple reporting periods (see Section 7.3.4). The end date of any verification period must correspond to the end date of a reporting period.

A project developer may choose to utilize one option for the duration of a project's crediting period, or may choose different options at different points during a single crediting period. Regardless of the option selected, reporting periods must be contiguous; there may be no time gaps in reporting during the crediting period of a project once the initial reporting period has commenced.

7.3.1 Initial Reporting and Verification Period

While a reporting period cannot exceed 12 months, a project developer may register multiple reporting periods (i.e. more than 12 months of data) during a project's initial verification period. A project developer may also register a project's initial verification period as a zero-credit reporting period (see the Reserve Program Manual for more information on zero-credit reporting periods).

Once a project is registered and has had at least 3 months of emission reductions verified, the project developer may choose one of the verification options below.

7.3.2 Option 1: Twelve-Month Maximum Verification Period

Under this option, the verification period may not exceed 12 months. Verification with a site visit is required for CRT issuance. The project developer may choose to have a sub-annual verification period (e.g. quarterly or semi-annually).

7.3.3 Option 2: Twelve-Month Verification Period with Desktop Verification

Under this option, the verification period cannot exceed 12 months. However, CRTs may be issued upon successful completion of a desktop verification as long as: (1) site-visit verifications occur at two-year intervals; and (2) the verifier has confirmed that there have been no significant changes in data management systems, equipment, or personnel since the previous site visit. Desktop verifications must cover all other required verification activities.

In order to utilize this option, there are two additional requirements that must be satisfied:

1. Prior to a desktop verification commencing, the project developer must attest to the verifier that there have been no significant changes to the project's data management systems, project set up/equipment, or site personnel involved with the project since the last site-visit verification. For each verification period, the project developer must provide the following documentation for review by the verifier prior to the desktop verification commencing:
    a. A schematic of system equipment and configuration, detailing any changes since the previous site visit, and any other supporting documentation for system or operation changes
    b. A list of personnel performing key functions related to project activities (personnel who manage and perform monitoring, measurement, and instrument QA/QC activities for the project), and documentation of any personnel or roles or changes since the pervious site visit; this shall include documented handover of personnel changes, including personnel change dates
    c. The sections from the Monitoring Plan that summarize the data management systems and processes in place and a summary of any changes to the systems or processes since the previous site visit

2. Desktop verifications must be conducted by the same verification body that conducted the most recent site-visit verification.

For projects using this option, the initial verification in this cycle shall be a full verification, including a site visit, and shall cover a minimum of 3 months and maximum 12 months of project data. All subsequent verification periods under this option shall be 12-month verification periods. Projects that wish to upgrade to the latest protocol version from a previous version whilst simultaneously taking advantage of the desktop verification option shall be allowed to do so, provided:

i. The verification of the previous verification period (e.g. under Version 2.1, 2.2 or 3.0) was a full verification, including site visit, and covered a minimum of 3 months of project data, and
ii. The two additional requirements specified in Section 7.3.3 are satisfied.

Taking into consideration the Reserve's policy that a verification body may provide verification services to a project for a maximum of six consecutive years (see the Verification Program Manual, Section 2.6 for more information), Table 7.1 below details what the verification cycle might look under Option 2.

Table 7.1. Sample Verification Cycle under Option 2

Reporting Period	Verification Activity	Verification Body (VB)
Year 1 *(initial verification)*	Site-visit verification	VB A
Year 2	Desktop verification	VB A
Year 3	Site-visit verification	VB A
Year 4	Desktop verification	VB A
Year 5	Site-visit verification	VB A
Year 6	Desktop verification	VB A
Year 7	Site-visit verification	VB B *(new verification body)*
Year 8	Desktop verification	VB B

7.3.4 Option 3: Twenty-Four Month Maximum Verification Period

Under this option, the verification period cannot exceed 24 months and the project's monitoring report must be submitted to the Reserve for the interim 12 month reporting period. The project monitoring report must be submitted for projects that choose Option 3 to meet the annual documentation requirement of the Reserve program. It is meant to provide the Reserve with information and documentation on a project's operations and performance, and adherence to the project's monitoring plan. It is submitted via the Reserve's online registry, but is not a publicly available document. A monitoring report template for livestock projects is available at http://www.climateactionreserve.org/how/program/documents/. The monitoring report shall be submitted within 30 days of the end of the interim reporting period. The only exception to this requirement is for projects that verify under Option 3 as part of a protocol upgrade, and fall within the specific timeline outlined below.

Project developers that wish to upgrade to Version 4.0 of this protocol and immediately utilize the 24-month verification period shall be allowed to do so, provided that the verification of the previous verification period (e.g. under Version 2.0, 2.1, 2.2, or 3.0) was a full verification, including a site visit, and covered a minimum of 3 months of project data.

All project developers utilizing the 24-month verification period must submit the monitoring report within 30 days of the end of the interim reporting period.

Under this option, CRTs may be issued upon successful completion of a site-visit verification for GHG reductions achieved over a maximum of 24 months. CRTs will not be issued based on the Reserve's review of project monitoring plans/reports. Project developers may choose to have a verification period shorter than 24 months.

Taking into consideration the Reserve's policy that a verification body may provide verification services to a project for a maximum of six consecutive years (see the Verification Program Manual, Section 2.6 for more information), Table 7.2 below details what the verification cycle might look under Option 3.

Table 7.2. Sample Verification Cycle under Option 3

Reporting Period	Verification Activity	Verification Body (VB)
Year 1 *(initial verification)*	Site-visit verification	VB A
Year 2	Project monitoring plan and report submitted to Reserve	n/a
Year 3	Site-visit verification for years 2 & 3	VB A
Year 4	Project monitoring plan and report submitted to Reserve	n/a
Year 5	Site-visit verification for years 4 & 5	VB A
Year 6	Project monitoring plan and report submitted to Reserve	n/a
Year 7	Site-visit verification for years 6 & 7	VB B *(new verification body)*
Year 8	Project monitoring plan and report submitted to Reserve	n/a

8 Verification Guidance

This section provides verification bodies with guidance on verifying GHG emission reductions associated with installing a biogas control system for manure management on dairy cattle and swine farms. This verification guidance supplements the Reserve's Verification Program Manual and describes verification activities specifically related to livestock manure management projects.

Verification bodies trained to verify livestock projects must be familiar with the following documents:

- Climate Action Reserve Program Manual
- Climate Action Reserve Verification Program Manual
- Climate Action Reserve U.S. Livestock Project Protocol

The Reserve's Program Manual, Verification Program Manual, and project protocols are designed to be compatible with each other and are available on the Reserve's website at http://www.climateactionreserve.org.

In cases where the Program Manual and/or Verification Program Manual differ from the guidance in this protocol, this protocol takes precedent.

Only Reserve-approved verification bodies are eligible to verify livestock project reports. Verification bodies approved under other project protocol types are not permitted to verify livestock projects. Information about verification body accreditation and Reserve project verification training can be found on the Reserve website at http://www.climateactionreserve.org.

8.1 Standard of Verification

The Reserve's standard of verification for livestock projects is the U.S. Livestock Project Protocol (this document), the Reserve Program Manual, and the Verification Program Manual. To verify a livestock project report, verification bodies apply the guidance in the Verification Program Manual and this section of the protocol to the standards described in Sections 2 through 7 of this protocol. Sections 2 through 7 provide eligibility rules, methods to calculate emission reductions, performance monitoring instructions and requirements, and procedures for reporting project information to the Reserve.

8.2 Monitoring Plan

The Monitoring Plan serves as the basis for verification bodies to confirm that the monitoring and reporting requirements in Section 6 and Section 7 have been met, and that consistent, rigorous monitoring and record-keeping is ongoing at the project site. Verification bodies shall confirm that the Monitoring Plan covers all aspects of monitoring and reporting contained in this protocol and specifies how data for all relevant parameters in Section 6 are collected and recorded.

8.3 Verifying Project Eligibility

Verification bodies must affirm a livestock project's eligibility according to the rules described in this protocol. The table below outlines the eligibility criteria for livestock projects. This table does not present all criteria for determining eligibility comprehensively; verification bodies must also look to Section 3 and the verification items list in Table 8.2.

Table 8.1. Summary of Eligibility Criteria for a Livestock Project

Eligibility Rule	Eligibility Criteria	Frequency of Rule Application
Start Date	Projects must be submitted for listing within 6 months of the project start date	Once during first verification
Location	United States, its territories, and U.S. tribal areas	Once during first verification
Performance Standard Test	Installation of a biogas control system that captures and destroys methane gas from anaerobic manure treatment and/or storage facilities on livestock operations	Once during first verification
Anaerobic Baseline	Projects must demonstrate that the depth of the anaerobic lagoons or ponds prior to the project's implementation were sufficient to prevent algal oxygen production and create an oxygen-free bottom layer; which means at least 1 meter in liquid depth	Once during first verification
Legal Requirement Test	Signed Attestation of Voluntary Implementation form and additional documentation demonstrating that the project passes the Legal Requirement Test	Once during first verification for first crediting period; every verification for second crediting period
Regulatory Compliance	Signed Attestation of Regulatory Compliance form and disclosure of all non-compliance events to verifier, and monitoring; project must be in material compliance with all applicable laws	Every verification

8.4 Core Verification Activities

The U.S. Livestock Project Protocol provides explicit requirements and guidance for quantifying the GHG reductions associated with installing a BCS to capture and destroy methane gas from livestock operations. The Verification Program Manual describes the core verification activities that shall be performed by verification bodies for all project verifications. They are summarized below in the context of a livestock project, but verification bodies must also follow the general guidance in the Verification Program Manual.

Verification is a risk assessment and data sampling effort designed to ensure that the risk of reporting error is assessed and addressed through appropriate sampling, testing, and review. The three core verification activities are:

1. Identifying emission sources, sinks, and reservoirs
2. Reviewing GHG management systems and estimation methodologies
3. Verifying emission reduction estimates

Identifying emission sources, sinks, and reservoirs

The verification body reviews for completeness the SSRs identified for a project, such as energy use waste collection and transport, treatment and storage, and uncombusted methane from the biogas control system.

Reviewing GHG management systems and estimation methodologies

The verification body reviews and assesses the appropriateness of the methodologies and management systems that the livestock project operator uses to gather data and calculate baseline and project emissions. This includes the examination of assertions or assumptions regarding MS, the percentage of manure going to anaerobic treatment systems in the baseline, and the baseline lagoon cleaning frequency.

Verifying emission reduction estimates

The verification body further investigates areas that have the greatest potential for material misstatements and then confirms whether or not material misstatements have occurred. This involves site visits to the project to ensure the systems on the ground correspond to and are consistent with data provided to the verification body. In addition, the verification body recalculates a representative sample of the performance or emissions data for comparison with data reported by the project developer in order to double-check the calculations of GHG emission reductions.

8.5 Verification Period

Per Section 7.3, this protocol provides project developers three verification options for a project after its initial verification and registration in order to provide flexibility and help manage verification costs associated with livestock projects. The different options require verification bodies to confirm additional requirements specific to this protocol, and in some instances, to utilize professional judgment on the appropriateness of the option selected.

8.5.1 Option 1: Twelve-Month Maximum Verification Period

Option 1 does not require verification bodies to confirm any additional requirements beyond what is specified in the protocol.

8.5.2 Option 2: Twelve-Month Verification Period with Desktop Verification

Option 2 requires verification bodies to review the documentation specified in Section 7.3.3 in order to determine if a desktop verification is appropriate. The verifier shall use his/her professional judgment to assess any changes that have occurred related to a project’s data management systems, equipment, or personnel and determine whether a site visit should be required as part of verification activities in order to provide a reasonable level of assurance on the project’s verification. The documentation shall be reviewed prior to the COI/NOVA renewal being submitted to the Reserve, and the verification body shall provide a summary of its assessment and decision on the appropriateness of a desktop verification when submitting the COI/NOVA renewal. The Reserve reserves the right to review the documentation provided by the project developer and the decision made by the verification body on whether a desktop verification is appropriate.

8.5.3 Option 3: Twenty-Four Month Maximum Verification Period

Under Option 3 (see Section 7.3.4), verification bodies shall look to the project monitoring report submitted by the project developer to the Reserve for the interim 12 month reporting period as a resource to inform its planned verification activities. While verification bodies are not expected to provide a reasonable level of assurance on the accuracy of the monitoring report as part of verification, the verification body shall list a summary of discrepancies between the monitoring report and what was ultimately verified in the List of Findings.

8.6 Livestock Verification Items

The following tables provide lists of items that a verification body needs to address while verifying a livestock project. The tables include references to the section in the protocol where requirements are further specified. The table also identifies items for which a verification body is expected to apply professional judgment during the verification process. Verification bodies are expected to use their professional judgment to confirm that protocol requirements have been met in instances where the protocol does not provide (sufficiently) prescriptive guidance. For more information on the Reserve's verification process and professional judgment, please see the Verification Program Manual.

Note: These tables shall not be viewed as a comprehensive list or plan for verification activities, but rather guidance on areas specific to livestock projects that must be addressed during verification.

8.6.1 Project Eligibility and CRT Issuance

Table 8.2 lists the criteria for reasonable assurance with respect to eligibility and CRT issuance for livestock projects. These requirements determine if a project is eligible to register with the Reserve and/or have CRTs issued for the reporting period. If any requirement is not met, either the project may be determined ineligible or the GHG reductions from the reporting period (or sub-set of the reporting period) may be ineligible for issuance of CRTs, as specified in Sections 2, 3, and 6.

Table 8.2. Eligibility Verification Items

Protocol Section	Eligibility Qualification Item	Apply Professional Judgment?
2.1	Verify that the project meets the definition of a livestock project	No
2.2	Verify ownership of the reductions by reviewing Attestation of Title and other relevant contracts, documentation	No
3.2	Verify eligibility of project start date	No
3.2	Verify accuracy of project start date based on operational records	Yes
3.3	Verify that project is within its 10-year crediting period	No
3.4	Verify that all pre-project manure treatment lagoons/ponds/tanks were of sufficient depth to ensure an oxygen free bottom layer (> 1m)	Yes
3.4	Verify that the pre-project manure management system met the requirements of this section for the relevant period of time	Yes
3.4	If the project is a greenfield project, verify that the project site meets the definition of a greenfield	Yes
3.5.1	Verify that the project meets the Performance Standard Test	No
3.5.2	Confirm execution of the Attestation of Voluntary Implementation form to demonstrate eligibility under the Legal Requirement Test (initial verification only)	No
3.6	Verify that the project activities comply with applicable laws by reviewing instances of non-compliance provided by the project developer and performing a risk-based assessment to confirm the statements made by the project developer in the Attestation of Regulatory Compliance form	Yes
6	Verify that monitoring meets the requirements of the protocol. If it does not, verify that variance has been approved for monitoring variations	No
6	Verify that all gas flow meters and continuous methane analyzers adhered to the inspection, cleaning, and calibration schedule specified in the protocol. If they do not, verify that a variance has been approved for	No

Protocol Section	Eligibility Qualification Item	Apply Professional Judgment?
	monitoring variations or that adjustments have been made to data per the protocol requirements	
6	Verify that adjustments for failed calibrations were properly applied	No
6, Appendix D	If used, verify that data substitution methodology was properly applied	No

8.6.2 Quantification

Table 8.3 lists the items that verification bodies shall include in their risk assessment and re-calculation of the project's GHG emission reductions. These quantification items inform any determination as to whether there are material and/or immaterial misstatements in the project's GHG emission reduction calculations. If there are material misstatements, the calculations must be revised before CRTs are issued.

Table 8.3. Quantification Verification Items

Protocol Section	Quantification Item	Apply Professional Judgment?
4	Verify that all SSRs in the GHG Assessment Boundary are accounted for	No
5	Verify that the modeled baseline is compared with the total amount of methane metered and destroyed by the project, and the lesser of the two values is used as the baseline for the GHG reduction calculation	No
5.1	Verify that the livestock categories (L) are correctly differentiated	Yes
5.1	Verify that the project developer applied the correct VS and B_0 values for each livestock category	No
5.1, 6.1	If site-specific B_0 values were developed, verify that the sampling and analysis procedures were correctly followed	Yes
5.1	Verify that the fraction of manure (MS) handled by the different manure management system components (i.e. GHG source) is satisfactorily represented	Yes
5.1	Verify that the baseline lagoon cleaning frequency is satisfactorily represented	Yes
5.1	Verify that the project developer used methane conversion factors (MCF) differentiated by temperature	No
5.1	Verify that the methane baseline emissions calculations for each livestock category were calculated according to the protocol with the appropriate data	No
5.1	Verify that the project developer correctly aggregated methane emissions from sources within each livestock category	Yes
5.4	Verify that the project developer correctly monitored, quantified and aggregated electricity use	Yes
5.2, 5.4	Verify that the project developer correctly monitored, quantified and aggregated fossil fuel use	Yes
5.2, 5.4	Verify that the project developer applied the correct emission factors for fossil fuel combustion and grid-delivered electricity	No
5.2	Verify that the project developer applied the correct methane destruction efficiencies	No
5.2	Verify that the project developer applied the correct B_0 value for Modeled Project Methane Emissions from Anaerobic Treatment of BCS Effluent	No
5.2	Verify that the project developer correctly quantified the amount of uncombusted methane	No

Protocol Section	Quantification Item	Apply Professional Judgment?
5.2	Verify that methane emissions resulting from any venting event are estimated correctly	Yes
5.2, 5.4	Verify that the project emissions calculations were calculated according to the protocol with the appropriate data	No
5.2, 5.1	Verify that the project developer assessed baseline and project emissions on a month-to-month basis	No
5.2	Verify that the project developer correctly monitored and quantified the amount of methane destroyed by the project	No
5.3	Verify that the modeled methane emission reductions are compared with the *ex-post* methane metered and destroyed by the project, and the lesser of the two values is used to quantify project emission reductions	No

8.6.3 Risk Assessment

Verification bodies will review the following items in Table 8.4 to guide and prioritize their assessment of data used in determining eligibility and quantifying GHG emission reductions.

Table 8.4. Risk Assessment Verification Items

Protocol Section	Item that Informs Risk Assessment	Apply Professional Judgment?
6	Verify that the project Monitoring Plan is sufficiently rigorous to support the requirements of the protocol and proper operation of the project	Yes
6	Verify that the BCS was operated and maintained according to manufacturer specifications	No
6	Verify that appropriate monitoring equipment is in place to meet the requirements of the protocol	No
6	Verify that the individual or team responsible for managing and reporting project activities are qualified to perform this function	Yes
6	Verify that appropriate training was provided to personnel assigned to greenhouse gas reporting duties	Yes
6	Verify that all contractors are qualified for managing and reporting greenhouse gas emissions if relied upon by the project developer. Verify that there is internal oversight to assure the quality of the contractor's work	Yes
7.2	Verify that all required records have been retained by the project developer	No

8.7 Completing Verification

The Verification Program Manual provides detailed information and instructions for verification bodies to finalize the verification process. It describes completing a Verification Report, preparing a Verification Statement, submitting the necessary documents to the Reserve, and notifying the Reserve of the project's verified status.

9 Glossary of Terms

Accredited verifier	A verification firm approved by the Reserve to provide verification services for project developers.
Additionality	Manure management practices that are above and beyond business-as-usual operation, exceed the baseline characterization, and are not mandated by regulation.
Anaerobic	Pertaining to or caused by the absence of oxygen.
Anthropogenic emissions	GHG emissions resultant from human activity that are considered to be an unnatural component of the Carbon Cycle (i.e. fossil fuel combustion, deforestation etc.).
Biogas	The mixture of gas (largely methane) produced as a result of the anaerobic decomposition of livestock manure.
Biogas control system (BCS)	A system designed to capture and destroy the biogas that is produced by the anaerobic treatment and/or storage of livestock manure and/or other organic material. Commonly referred to as a "digester."
Biogenic CO_2 emissions	CO_2 emissions resulting from the combustion and/or aerobic decomposition of organic matter. Biogenic emissions are considered to be a natural part of the carbon cycle, as opposed to anthropogenic emissions.
Carbon dioxide (CO_2)	The most common of the six primary greenhouse gases, consisting of a single carbon atom and two oxygen atoms.
CO_2 equivalent (CO_2e)	The quantity of a given GHG multiplied by its total global warming potential. This is the standard unit for comparing the degree of warming which can be caused by different GHGs.
Direct emissions	Greenhouse gas emissions from sources that are owned or controlled by the reporting entity.
Emission factor	A unique value for determining an amount of a greenhouse gas emitted for a given quantity of activity data (e.g. metric tons of carbon dioxide emitted per barrel of fossil fuel burned).
Flare	A destruction device that uses an open flame to burn combustible gases with combustion air provided by uncontrolled ambient air around the flame.
Fossil fuel	A fuel, such as coal, oil, and natural gas, produced by the decomposition of ancient (fossilized) plants and animals.
Greenfield	For the purposes of this protocol, a livestock facility that has been in operation for less than two years at a site that had no prior manure management infrastructure.
Greenhouse gas	Carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O),

(GHG)	sulfur hexafluoride (SF_6), hydrofluorocarbons (HFCs) or perfluorocarbons (PFCs).
Global warming potential (GWP)	The ratio of radiative forcing (degree of warming to the atmosphere) that would result from the emission of one unit of a given GHG compared to one unit of CO_2.
Indirect emissions	Emissions that are a consequence of the actions of a reporting entity, but are produced by sources owned or controlled by another entity.
Livestock project	Installation of a biogas control system that, in operation, causes a decrease in GHG emissions from the baseline scenario through destruction of the methane component of biogas.
Metric ton (tonne, MT, t)	A common international measurement for the quantity of GHG emissions, equivalent to about 2204.6 pounds or 1.1 short tons.
Methane (CH_4)	A potent GHG with a GWP of 21, consisting of a single carbon atom and four hydrogen atoms.
MMBtu	One million British thermal units.
Mobile combustion	Emissions from the transportation of materials, products, waste, and employees resulting from the combustion of fuels in company owned or controlled mobile combustion sources (e.g. cars, trucks, tractors, dozers, etc.).
Nitrous oxide (N_2O)	A GHG consisting of two nitrogen atoms and a single oxygen atom.
Project baseline	A business-as-usual GHG emission assessment against which GHG emission reductions from a specific GHG reduction activity are measured.
Project developer	An entity that undertakes a project activity, as identified in the Livestock Project Protocol. A project developer may be an independent third party or the dairy/swine operating entity.
Reporting period	The period of time over which a project developer quantifies and reports GHG reductions to the Reserve. Under this protocol, the reporting period cannot exceed 12 months.
Stationary combustion source	A stationary source of emissions from the production of electricity, heat, or steam, resulting from combustion of fuels in boilers, furnaces, turbines, kilns, and other facility equipment.
van't Hoff-Arrhenius factor (*f*)	The proportion of volatile solids that are biologically available for conversion to methane based on the monthly temperature of the system.[38]

[38] Mangino, et al.

Verification	The process used to ensure that a given participant's greenhouse gas emissions or emission reductions have met the minimum quality standard and complied with the Reserve's procedures and protocols for calculating and reporting GHG emissions and emission reductions.
Verification body	An accredited firm that is able to render a verification opinion and provide verification services for operators subject to reporting under this protocol.
Verification period	The period of time over which GHG reductions are verified. Under this protocol, a verification period may cover multiple reporting periods (see Section 7.3.4). The end date of any verification period must correspond to the end date of a reporting period.

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Appendix A Associated Environmental Impacts

Manure management projects have many documented environmental benefits, including air emission reductions, water quality protection, and electricity generation. These benefits are the result of practices and technologies that are well managed, well implemented, and well designed. However, in cases where practices or technologies are poorly or improperly designed, implemented, and/or managed, local air and water quality could be compromised.

With regard to air quality, there are a number of factors that must be considered and addressed to realize the environmental benefits of a biogas project and reduce or avoid potential negative impacts. Uncontrolled emissions from combustion of biogas may contain between 200 to 300 ppm NOx. The anaerobic treatment process creates intermediates such as ammonia, hydrogen sulfide, orthophosphates, and various salts, all of which must be properly controlled or captured. In addition, atmospheric releases at locations off-site where bio-gas is shipped may negate or decrease the benefit of emissions controls on-site. Thus, while devices such as Selective Catalyst Reduction (SCR) units can reduce NOx emissions and proper treatment system operation can control intermediates, improper design or operation may lead to violations of federal, state, and local air quality regulations as well as release of toxic air contaminants.

With regard to water quality, it is critical that project developers and managers ensure digester integrity and fully consider and address post-digestion management of the effluent in order to avoid contamination of local waterways and groundwater resources. Catastrophic digester failures; leakage from pipework and tanks; and lack of containment in waste storage areas are all examples of potential problems. Further, application of improperly treated digestate and/or improper application timing or rates of digestate to agricultural land may lead to increased nitrogen oxide emissions, soil contamination, and/or nutrient leaching, thus negating or reducing benefits of the project overall.

Project developers must not only follow the protocol to register GHG reductions with the Reserve, they must also comply with all local, state, and national air and water quality regulations. Projects must be designed and implemented to mitigate potential releases of pollutants such as those described, and project managers must acquire the appropriate local permits prior to installation to prevent violation of the law.

The Reserve agrees that GHG emission reduction projects should not undermine air and water quality efforts and will work with stakeholders to establish initiatives to meet both climate-related and localized environmental objectives.

Appendix B Emission Factor Tables

Table B.1. Manure Management System Components

System	Definition
Pasture/Range/ Paddock	The manure from pasture and range grazing animals is allowed to lie as deposited, and is not managed.
Daily spread	Manure is routinely removed from a confinement facility and is applied to cropland or pasture within 24 hours of excretion.
Solid storage	The storage of manure, typically for a period of several months, in unconfined piles or stacks. Manure is able to be stacked due to the presence of a sufficient amount of bedding material or loss of moisture by evaporation.
Dry lot	A paved or unpaved open confinement area without any significant vegetative cover where accumulating manure may be removed periodically.
Liquid/Slurry	Manure is stored as excreted or with some minimal addition of water in either tanks or earthen ponds outside the animal housing, usually for periods less than one year. Per IPCC Guidelines, if manure contains less than 20% dry matter it can be considered liquid.
Uncovered anaerobic lagoon	A type of liquid storage system designed and operated to combine waste stabilization and storage. Lagoon supernatant is usually used to remove manure from the associated confinement facilities to the lagoon. Anaerobic lagoons are designed with varying lengths of storage (up to a year or greater), depending on the climate region, the volatile solids loading rate, and other operational factors. The water from the lagoon may be recycled as flush water or used to irrigate and fertilize fields.
Pit storage below animal confinements	Collection and storage of manure usually with little or no added water typically below a slatted floor in an enclosed animal confinement facility, usually for periods less than one year.
Anaerobic digester	Animal excreta with or without straw are collected and anaerobically digested in a large containment vessel or covered lagoon. Digesters are designed and operated for waste stabilization by the microbial reduction of complex organic compounds to CO2 and CH4, which is captured and flared or used as a fuel.
Burned for fuel	The dung and urine are excreted on fields. The sun dried dung cakes are burned for fuel.
Cattle and Swine deep bedding	As manure accumulates, bedding is continually added to absorb moisture over a production cycle and possibly for as long as 6 to 12 months. This manure management system also is known as a bedded pack manure management system and may be combined with a dry lot or pasture.
Composting – In-vessel*	Composting, typically in an enclosed channel, with forced aeration and continuous mixing.
Composting – Static pile*	Composting in piles with forced aeration but no mixing.
Composting – Intensive windrow*	Composting in windrows with regular (at least daily) turning for mixing and aeration.
Composting – Passive windrow*	Composting in windrows with infrequent turning for mixing and aeration.
Aerobic treatment	The biological oxidation of manure collected as a liquid with either forced or natural aeration. Natural aeration is limited to aerobic and facultative ponds and wetland systems and is due primarily to photosynthesis. Hence, these systems typically become anoxic during periods without sunlight.

*Composting is the biological oxidation of a solid waste including manure usually with bedding or another organic carbon source typically at thermophilic temperatures produced by microbial heat production.
Source: 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Chapter 10: Emissions from Livestock and Manure Management, Table 10.18: Definitions of Manure Management Systems, p. 10.49.

Table B.2. Livestock Categories and Typical Animal Mass

Livestock Category (L)	Livestock Typical Animal Mass (TAM) in kg	
	2006 - 2008	2009 - 2010
Dairy cows (on feed)	604[b]	680[c]
Non-milking dairy cows (on feed)	684[a]	684[a]
Heifers (on feed)	476[b]	407[c]
Bulls (grazing)	750[b]	750[c]
Calves (grazing)	118[b]	118[c]
Heifers (grazing)	420[b]	351[c]
Cows (grazing)	533[b]	582.5[c]
Nursery swine	12.5[a]	12.5[a]
Grow/finish swine	70[a]	70[a]
Breeding swine	198[b]	198[c]

Sources for TAM:
[a.] American Society of Agricultural Engineers (ASAE) Standards 2005, ASAE D384.2.
[b.] Environmental Protection Agency (EPA), Inventory of US GHG Emissions and Sinks 1990-2006 (2007), Annex 3, Table A-161, pg. A-195.
[c.] Environmental Protection Agency (EPA), Inventory of US GHG Emissions and Sinks 1990-2010 (2012), Annex 3, Table A-191, pg. A-246.

Table B.3. Volatile Solids and Maximum Methane Potential by Livestock Category

Livestock category (L)	VS_L (kg/day/1000 kg mass)	$B_{0,L}$ [b] (m^3 CH_4/kg VS added)
Dairy cows	See Appendix B, Tables 5a-e	0.24
Non-milking dairy cows	5.56	0.24
Heifers	See Appendix B, Tables 5a-e	0.17
Bulls (grazing)	6.04[b]	0.17
Calves (grazing)	6.41[b]	0.17
Heifers (grazing)	See Appendix B, Tables 5a-e	0.17
Cows (grazing)	See Appendix B, Tables 5a-e	0.17
Nursery swine	8.89[b]	0.48
Grow/finish swine	5.36[b]	0.48
Breeding swine	2.71[b]	0.35

[a.] American Society of Agricultural Engineers (ASAE) Standards 2005, ASAE D384.2, VS_L(kg/day per animal) from table 1.b (p.2) converted to (kg/day/1000 kg mass) using average Live Weight (kg)values from table 5c (p.7).
[b.] Environmental Protection Agency (EPA) – Climate Leaders Draft Manure Offset Protocol, October 2006, Table IIa: Animal Waste Characteristics (VS, B_0, and N_{ex} rates), p. 18.

Table B.4. Biogas Collection Efficiency by Digester Type

Digester Type	Cover Type	Biogas Collection Efficiency (BCE) as a Decimal
Covered Anaerobic Lagoon	Bank-to-Bank, impermeable	0.95
	Partial area (modular), impermeable	(0.95) x (% area covered)
Complete mix, plug flow, or fixed film digester	Enclosed vessel	0.98
Two stages of differing types	With flow metered for each stage	$\frac{(BCE1) \times (Gasflow1) + (BCE2) \times (Gasflow2)}{Total\ biogas\ flow}$
	No separate flow metering	$(BCE1) \times 0.7 + (BCE2) \times 0.3$

Adapted from: U.S. EPA Climate Leaders, Offset Project Methodology for Managing Manure and Biogas Recovery Systems, 2008. Table IIf (original table has been expanded upon).

Table B.5a. 2010 Volatile Solid Default Values for Dairy Cows, Heifers, Heifers-Grazing and Cows-Grazing by State (kg/day/1000 kg mass)

State	VS Dairy Cow	VS Heifer	VS Heifer-Grazing	VS Cows-Grazing
Alabama	8.99	8.43	8.53	7.82
Alaska	7.98	8.43	9.98	8.89
Arizona	11.47	8.43	9.77	8.89
Arkansas	8.30	8.43	8.48	7.82
California	11.27	8.43	9.48	8.89
Colorado	11.54	8.43	9.27	8.89
Connecticut	10.22	8.43	8.62	7.87
Delaware	9.53	8.43	8.53	7.87
Florida	10.26	8.43	8.63	7.82
Georgia	10.03	8.43	8.49	7.82
Hawaii	8.43	8.43	9.77	8.89
Idaho	11.24	8.43	9.41	8.89
Illinois	10.19	8.43	7.78	7.47
Indiana	10.54	8.43	7.91	7.47
Iowa	10.67	8.43	7.64	7.47
Kansas	10.74	8.43	7.61	7.47
Kentucky	9.11	8.43	8.40	7.82
Louisiana	7.98	8.43	8.63	7.82
Maine	9.94	8.43	8.51	7.87
Maryland	10.00	8.43	8.51	7.87
Massachusetts	9.67	8.43	8.53	7.87
Michigan	11.42	8.43	7.83	7.47
Minnesota	10.25	8.43	7.83	7.47
Mississippi	8.59	8.43	8.53	7.82
Missouri	8.81	8.43	7.97	7.47
Montana	10.63	8.43	8.42	7.82
Nebraska	10.38	8.43	9.25	8.89
Nevada	11.08	8.43	8.01	7.47
New Hampshire	10.40	8.43	9.62	8.89
New Jersey	9.69	8.43	8.45	7.87
New Mexico	11.81	8.43	8.43	7.87
New York	10.69	8.43	9.50	8.89
North Carolina	10.54	8.43	8.61	7.87
North Dakota	9.92	8.43	8.31	7.82
Ohio	10.27	8.43	7.95	7.47
Oklahoma	9.59	8.43	7.90	7.47
Oregon	10.54	8.43	8.33	7.82
Pennsylvania	10.39	8.43	9.56	8.89
Rhode Island	9.76	8.43	8.66	7.87
South Carolina	10.02	8.43	8.61	7.87
South Dakota	10.59	8.43	8.19	7.82
Tennessee	9.56	8.43	8.12	7.47
Texas	10.87	8.43	8.21	7.82
Utah	10.86	8.43	8.42	7.82
Vermont	10.00	8.43	9.56	8.89
Virginia	10.09	8.43	8.52	7.87
Washington	11.50	8.43	8.25	7.82
West Virginia	9.15	8.43	9.73	8.89
Wisconsin	10.63	8.43	7.96	7.47
Wyoming	10.46	8.43	9.62	8.89

Source: Environmental Protection Agency (EPA). U.S. Inventory of GHG Sources and Sinks 1990-2010 (2012), Annex 3, Table A-192, page A-237.

Table B.5b. 2009 Volatile Solid Default Values for Dairy Cows, Heifers, Heifers-Grazing and Cows-Grazing by State (kg/day/1000 kg mass)

State	VS Dairy Cow	VS Heifer	VS Heifer-Grazing	VS Cows-Grazing
Alabama	9.13	8.42	8.61	7.90
Alaska	7.43	8.42	11.51	10.15
Arizona	11.35	8.42	11.23	10.15
Arkansas	8.24	8.42	8.53	7.87
California	10.97	8.42	8.13	7.70
Colorado	11.37	8.42	7.42	7.27
Connecticut	10.05	8.42	8.53	7.77
Delaware	9.54	8.42	8.29	7.77
Florida	10.08	8.42	8.71	7.90
Georgia	10.24	8.42	8.61	7.90
Hawaii	8.70	8.42	11.32	10.15
Idaho	11.07	8.42	10.86	10.15
Illinois	10.10	8.42	8.10	7.77
Indiana	10.48	8.42	8.20	7.77
Iowa	10.55	8.42	7.98	7.77
Kansas	10.77	8.42	7.38	7.27
Kentucky	8.91	8.42	8.52	7.90
Louisiana	8.01	8.42	8.68	7.87
Maine	9.86	8.42	8.43	7.77
Maryland	9.92	8.42	8.32	7.77
Massachusetts	9.71	8.42	8.43	7.77
Michigan	11.18	8.42	8.15	7.77
Minnesota	10.21	8.42	8.17	7.77
Mississippi	8.82	8.42	8.60	7.90
Missouri	8.83	8.42	8.33	7.77
Montana	10.42	8.42	7.83	7.27
Nebraska	10.36	8.42	7.42	7.27
Nevada	10.99	8.42	11.14	10.15
New Hampshire	10.30	8.42	8.37	7.77
New Jersey	9.81	8.42	8.34	7.77
New Mexico	11.74	8.42	11.06	10.15
New York	10.46	8.42	8.20	7.77
North Carolina	10.55	8.42	8.60	7.90
North Dakota	9.46	8.42	7.68	7.27
Ohio	10.06	8.42	8.28	7.77
Oklahoma	9.55	8.42	8.32	7.87
Oregon	10.36	8.42	11.03	10.15
Pennsylvania	10.25	8.42	8.20	7.77
Rhode Island	9.78	8.42	8.55	7.77
South Carolina	10.29	8.42	8.64	7.90
South Dakota	10.48	8.42	7.57	7.27
Tennessee	9.53	8.42	8.58	7.90
Texas	10.73	8.42	8.26	7.87
Utah	10.74	8.42	11.11	10.15
Vermont	9.93	8.42	8.23	7.77
Virginia	10.08	8.42	8.56	7.90
Washington	11.39	8.42	10.93	10.15
West Virginia	8.85	8.42	8.35	7.77
Wisconsin	10.46	8.42	8.33	7.77
Wyoming	10.08	8.42	7.72	7.27

Source: Environmental Protection Agency (EPA). U.S. Inventory of GHG Sources and Sinks 1990-2009 (2011), Annex 3, Table A-186, page A-225.

Table B.5c. 2008 Volatile Solid Default Values for Dairy Cows, Heifers, Heifers-Grazing and Cows-Grazing by State (kg/day/1000 kg mass)

State	VS Dairy Cow	VS Heifer	VS Heifer-Grazing	VS Cows-Grazing
Alabama	8.40	8.35	7.81	7.02
Alaska	7.30	8.35	10.05	9.02
Arizona	10.37	8.35	10.34	9.02
Arkansas	7.59	8.35	7.86	7.00
California	10.02	8.35	7.95	6.85
Colorado	10.25	8.35	7.69	6.46
Connecticut	9.22	8.35	7.67	6.90
Delaware	8.63	8.35	7.72	6.90
Florida	8.90	8.35	7.75	7.02
Georgia	9.07	8.35	7.85	7.02
Hawaii	7.00	8.35	10.26	9.02
Idaho	10.11	8.35	10.82	9.02
Illinois	9.07	8.35	8.07	6.91
Indiana	9.38	8.35	7.98	6.91
Iowa	9.46	8.35	8.27	6.91
Kansas	9.63	8.35	7.75	6.46
Kentucky	7.89	8.35	7.91	7.02
Louisiana	7.39	8.35	7.73	7.00
Maine	8.99	8.35	7.76	6.90
Maryland	9.02	8.35	7.76	6.90
Massachusetts	8.63	8.35	7.74	6.90
Michigan	10.05	8.35	7.99	6.91
Minnesota	9.17	8.35	8.04	6.91
Mississippi	8.19	8.35	7.82	7.02
Missouri	8.02	8.35	7.85	6.91
Montana	9.03	8.35	7.17	6.46
Nebraska	9.09	8.35	7.71	6.46
Nevada	9.65	8.35	10.49	9.02
New Hampshire	9.44	8.35	7.74	6.90
New Jersey	8.51	8.35	7.89	6.90
New Mexico	10.34	8.35	10.56	9.02
New York	9.42	8.35	8.02	6.90
North Carolina	9.38	8.35	7.83	7.02
North Dakota	8.40	8.35	7.43	6.46
Ohio	9.01	8.35	7.93	6.91
Oklahoma	8.58	8.35	8.08	7.00
Oregon	9.40	8.35	10.54	9.02
Pennsylvania	9.26	8.35	8.00	6.90
Rhode Island	8.94	8.35	7.60	6.90
South Carolina	9.05	8.35	7.81	7.02
South Dakota	9.45	8.35	7.50	6.46
Tennessee	8.60	8.35	7.86	7.02
Texas	9.51	8.35	8.21	7.00
Utah	9.70	8.35	10.51	9.02
Vermont	9.03	8.35	7.89	6.90
Virginia	9.02	8.35	7.87	7.02
Washington	10.36	8.35	10.77	9.02
West Virginia	8.13	8.35	7.74	6.90
Wisconsin	9.34	8.35	7.87	6.91
Wyoming	9.29	8.35	7.30	6.46

Source: Environmental Protection Agency (EPA). U.S. Inventory of GHG Sources and Sinks 1990-2008 (2010), Annex 3, Table A-181, page A-213.

For VS values for reporting years prior to 2008, please refer to the Livestock Project Protocol V3.0, Appendix B.

Table B.6. IPCC 2006 Methane Conversion Factors by Manure Management System Component/Methane Source 'S' [39]

MCF Values by Temperature for Manure Management Systems																				
	Average annual temperature (°C)																			
	Cool					Temperate											Warm			
System[a]	**<10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**>28**	**Source and comments**
Pasture/Range/Paddock	0.010					0.015											0.020			Judgment of IPCC Expert Group in combination with Hashimoto and Steed (1994).
Daily spread	0.001					0.005											0.010			Hashimoto and Steed (1993).
Solid storage	0.02					0.04											0.05			Judgment of IPCC Expert Group in combination with Amon et al. (2001), which shows emissions of approximately 2% in winter and 4% in summer. Warm climate is based on judgment of IPCC Expert Group and Amon et al. (1998).
Dry lot	0.010					0.015											0.020			Judgment of IPCC Expert Group in combination with Hashimoto and Steed (1994).
Liquid/slurry w/natural crust cover[40]	0.10	0.11	0.13	0.14	0.15	0.17	0.18	0.20	0.22	0.24	0.26	0.29	0.31	0.34	0.37	0.41	0.44	0.48	0.50	Judgment of IPCC Expert Group in combination with Mangino et al. (2001) and Sommer (2000). The estimated reduction due to the crust cover (40%) is an annual average value based on a limited data set and can be highly variable dependent on temperature, rainfall, and composition.
Liquid/slurry uncovered	0.17	0.19	0.20	0.22	0.25	0.27	0.29	0.32	0.35	0.39	0.42	0.46	0.50	0.55	0.60	0.65	0.71	0.78	0.80	Judgment of IPCC Expert Group in combination with Mangino et al. (2001).
Uncovered anaerobic lagoon	0.66	0.68	0.70	0.71	0.73	0.74	0.75	0.76	0.77	0.77	0.78	0.78	0.78	0.79	0.79	0.79	0.79	0.80	0.80	Judgment of IPCC Expert Group in combination with Mangino et al. (2001). Uncovered lagoon MCFs vary based on several factors, including temperature, retention time, and loss of volatile solids from the system (through removal of lagoon effluent and/or solids).
Pit storage below animal confinements (<1 month)	0.03					0.03											0.03			Judgment of IPCC Expert Group in combination with Moller et al. (2004) and Zeeman (1994). Note that the ambient temperature, not the stable temperature is to be used for determining the climatic conditions.
Pit storage below animal confinements (>1 month)	0.17	0.19	0.20	0.22	0.25	0.27	0.29	0.32	0.35	0.39	0.42	0.46	0.50	0.55	0.60	0.65	0.71	0.78	0.80	Judgment of IPCC Expert Group in combination with Mangino et al. (2001). Note that the ambient temperature, not the stable temperature is to be used for determining the climatic conditions.

[39] Adapted from 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Chapter 10: Emissions from Livestock and Manure Management, Table 10.17. MCF values shall be chosen based on the average temperature at the site for an entire calendar year, even if the reporting period does not exactly cover a calendar year.

[40] A "natural crust cover" is a naturally-forming layer that covers the majority of the liquid surface at a thickness sufficient to support communities of oxidizing bacteria, and which persists throughout the year. Evidence of such a cover (including the area covered, thickness, and persistence) must be provided by the project developer during verification in order to justify the use of this MCF value.

Anaerobic digester	0 - 1					0 - 1											0 - 1			Should be subdivided in different categories, considering amount of recovery of the biogas, flaring of the biogas and storage after digestion. Calculation with Formula 1.
Burned for fuel	0.10					0.10											0.10			Judgment of IPCC Expert Group in combination with Safley et al. (1992).
Cattle and swine deep bedding (<1 month)	0.03					0.03											0.30			Judgment of IPCC Expert Group in combination with Moller et al. (2004). Expect emissions to be similar, and possibly greater, than pit storage, depending on organic content and moisture content.
Cattle and swine deep bedding (>1 month)	0.17	0.19	0.20	0.22	0.25	0.27	0.29	0.32	0.35	0.39	0.42	0.46	0.50	0.55	0.60	0.65	0.71	0.78	0.90	Judgment of IPCC Expert Group in combination with Mangino et al. (2001).
Composting - in-vessel or aerated static pile[b]	0.005					0.005											0.005			Judgment of IPCC Expert Group and Amon et al. (1998). MCFs are less than half of solid storage. Not temperature dependant.
Composting - passive or intensive windrow[b]	0.005					0.010											0.015			Judgment of IPCC Expert Group and Amon et al. (1998). MCFs are slightly less than solid storage. Less temperature dependant.
Aerobic treatment	0.00					0.00											0.00			MCFs are near zero. Aerobic treatment can result in the accumulation of sludge which may be treated in other systems. Sludge requires removal and has large VS values. It is important to identify the next management process for the sludge and estimate the emissions from that management process if significant.

[a] Definitions for manure management systems are provided in Table B.1.
[b] Composting is the biological oxidation of a solid waste, including manure, usually with bedding or another organic carbon source, typically at thermophilic temperatures produced by microbial heat production.

Table B.7. Biogas Destruction Efficiency Default Values by Destruction Device

If available, the official source tested methane destruction efficiency shall be used in place of the default methane destruction efficiency. Otherwise, project developers have the option to use either the default methane destruction efficiencies provided, or the site specific methane destruction efficiencies, for each of the combustion devices used in the project case performed on an annual basis. Site-specific values must be provided by an independent air emissions testing body that is accredited by a state or local regulatory agency, or the Stack Testing Accreditation Council. Where a state/region does not have an appropriate accreditation system or accredited service providers, the project developer may look to another state/region to find suitably qualified service providers.

Biogas Destruction Device	Biogas Destruction Efficiency (BDE)*
Open Flare	0.96[2]
Enclosed Flare	0.995[2]
Lean-burn Internal Combustion Engine	0.936[2]
Rich-burn Internal Combustion Engine	0.995[2]
Boiler	0.98[2]
Microturbine or large gas turbine	0.995[2]
Upgrade and use of gas as CNG/LNG fuel	0.95[2]
Upgrade and injection into natural gas transmission and distribution pipeline	0.98[3]
Direct pipeline to an end-user	Per corresponding destruction device

Source:
[1] Seebold, J.G., et al., Reaction Efficiency of Industrial Flares, 2003
[2] The default destruction efficiencies for this source are based on a preliminary set of actual source test data provided by the Bay Area Air Quality Management District. The default destruction efficiency values are the lesser of the twenty fifth percentile of the data provided or 0.995. These default destruction efficiencies may be updated as more source test data are made available to the Reserve.
[3] The Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories gives a standard value for the fraction of carbon oxidized for gas destroyed of 99.5% (Reference Manual, Table 1.6, page 1.29). It also gives a value for emissions from processing, transmission and distribution of gas which would be a very conservative estimate for losses in the pipeline and for leakage at the end user (Reference Manual, Table 1.58, page 1.121). These emissions are given as 118,000kgCH4/PJ on the basis of gas consumption, which is 0.6%. Leakage in the residential and commercial sectors is stated to be 0 to 87,000kgCH4/PJ, which equates to 0.4%, and in industrial plants and power station the losses are 0 to 175,000kg/CH4/PJ, which is 0.8%. These leakage estimates are compounded and multiplied. The methane destruction efficiency for landfill gas injected into the natural gas transmission and distribution system can now be calculated as the product of these three efficiency factors, giving a total efficiency of (99.5% * 99.4% * 99.6%) 98.5% for residential and commercial sector users, and (99.5% * 99.4% * 99.2%) 98.1% for industrial plants and power stations.[41]

[41] GE AES Greenhouse Gas Services, Landfill Gas Methodology, Version 1.0 (July 2007).

Table B.8. CO_2 Emission Factors for Fossil Fuel Use

Fuel Type	Heat Content	Carbon Content (Per Unit Energy)	Fraction Oxidized	CO_2 Emission Factor (Per Unit Energy)	CO_2 Emission Factor (Per Unit Mass or Volume)
Coal and Coke	**MMBTU / Short ton**	**kg C / MMBTU**		**kg CO_2 / MMBTU**	**kg CO_2 / Short ton**
Anthracite Coal	25.09	28.26	1.00	103.62	2,599.83
Bituminous Coal	24.93	25.49	1.00	93.46	2,330.04
Sub-bituminous Coal	17.25	26.48	1.00	97.09	1,674.86
Lignite	14.21	26.30	1.00	96.43	1,370.32
Unspecified (Residential/ Commercial)	22.05	26.00	1.00	95.33	2,102.29
Unspecified (Industrial Coking)	26.27	25.56	1.00	93.72	2,462.12
Unspecified (Other Industrial)	22.05	25.63	1.00	93.98	2,072.19
Unspecified (Electric Utility)	19.95	25.76	1.00	94.45	1,884.53
Coke	24.80	31.00	1.00	113.67	2,818.93
Natural Gas (By Heat Content)	**BTU / Standard ft^3**	**kg C / MMBTU**		**kg CO_2 / MMBTU**	**kg CO_2 / Standard ft^3**
975 to 1,000 Btu / Standard ft^3	975 – 1,000	14.73	1.00	54.01	Varies
1,000 to 1,025 Btu / Standard ft^3	1,000 – 1,025	14.43	1.00	52.91	Varies
1,025 to 1,050 Btu / Standard ft^3	1,025 – 1,050	14.47	1.00	53.06	Varies
1,050 to 1,075 Btu / Standard ft^3	1,050 – 1,075	14.58	1.00	53.46	Varies
1,075 to 1,100 Btu / Standard ft^3	1,075 – 1,100	14.65	1.00	53.72	Varies
Greater than 1,100 Btu / Standard ft^3	> 1,100	14.92	1.00	54.71	Varies
Weighted U.S. Average	1,029	14.47	1.00	53.06	0.0546
Petroleum Products	**MMBTU / Barrel**	**kg C / MMBTU**		**kg CO_2 / MMBTU**	**kg CO_2 / gallon**
Asphalt & Road Oil	6.636	20.62	1.00	75.61	11.95
Aviation Gasoline	5.048	18.87	1.00	69.19	8.32
Distillate Fuel Oil (#1, 2, and 4) (diesel)	5.825	19.95	1.00	73.15	10.15
Jet Fuel	5.670	19.33	1.00	70.88	9.57
Kerosene	5.670	19.72	1.00	72.31	9.76
LPG (average for fuel use)	3.849	17.23	1.00	63.16	5.79
Propane	3.824	17.20	1.00	63.07	5.74
Ethane	2.916	16.25	1.00	59.58	4.14
Isobutene	4.162	17.75	1.00	65.08	6.45
n-Butane	4.328	17.72	1.00	64.97	6.70
Lubricants	6.065	20.24	1.00	74.21	10.72
Motor Gasoline	5.218	19.33	1.00	70.88	8.81
Residual Fuel Oil (#5 and 6)	6.287	21.49	1.00	78.80	11.80
Crude Oil	5.800	20.33	1.00	74.54	10.29
Naphtha (<401°F)	5.248	18.14	1.00	66.51	8.31
Natural Gasoline	4.620	18.24	1.00	66.88	7.36
Other Oil (>401°F)	5.825	19.95	1.00	73.15	10.15
Pentanes Plus	4.620	18.24	1.00	66.88	7.36
Petrochemical Feedstocks	5.428	19.37	1.00	71.02	9.18
Petroleum Coke	6.024	27.85	1.00	102.12	14.65
Still Gas	6.000	17.51	1.00	64.20	9.17
Special Naphtha	5.248	19.86	1.00	72.82	9.10
Unfinished Oils	5.825	20.33	1.00	74.54	10.34
Waxes	5.537	19.81	1.00	72.64	9.58

Source: EPA Climate Leaders, Stationary Combustion Guidance (2007), Table B-2 except:
Default CO_2 emission factors (per unit energy) are calculated as: Carbon Content × Fraction Oxidized × 44/12.
Default CO_2 emission factors (per unit mass or volume) are calculated as: Heat Content x Carbon Content × Fraction Oxidized × 44/12× Conversion Factor (if applicable). Heat content factors are based on higher heating values (HHV).

Table B.9. Volatile Solids Removed Through Solids Separation[42]

Type of Solids Separation	Volatile Solids Removed (fraction)
Gravity	0.45
Mechanical:	
Stationary screen	0.17
Vibrating screen	0.15
Screw press	0.25
Centrifuge	0.50
Roller drum	0.25
Belt press/screen	0.50

Table B.10. Baseline Assumptions for Greenfield Projects[43]

Baseline Assumption	Dairy Cattle Operations		Swine Operations
	>200 Mature Dairy Cows	<200 Mature Dairy Cows	
Anaerobic manure storage system	Flush system into an anaerobic lagoon with >30 day retention time	Flush system into an anaerobic lagoon with >30 day retention time	Flush system into an anaerobic lagoon with >30 day retention time
Non-anaerobic manure storage system(s)	Solids storage	Solids Storage	Solids Storage
MS_L	90% lagoon 10% solids storage	50% lagoon 50% solids storage	95% lagoon 5% solids storage
Lagoon cleaning schedule	Annually, in September	Annually, in September	Annually, in September

[42] U.S.EPA National Pollutant Discharge Elimination System (NPDES) Development Document, Chapter 5, "Industry Subcategorization for Effluent Limitations Guidelines and Standards". Adapted from Moser et al. (1999).
[43] The simplified assumptions contained within this table are based on the waste management system data compiled by the U.S. Environmental Protection Agency for the development of Table A-194 in Annex 3 of the U.S. Inventory of GHG Sources and Sinks 1990-2010 (2012).

Appendix C Summary of Performance Standard Development

The analysis to establish a performance standard for the U.S. Livestock Project Protocol was undertaken by Science Applications International Corporation (SAIC) and independent consultant Kathryn Bickel Goldman. It took place at the end of 2006. The analysis culminated in a paper that provided a performance standard recommendation to support the Reserve's protocol development process, which the Reserve has incorporated into the protocol's eligibility rules (see Section 33). This analysis was re-visited during the development of Version 4.0 of the protocol and, although there was no recommended change to the performance standard, this appendix has been updated to reflect more recent data and analysis.

The purpose of a performance standard is to establish a threshold that is significantly better than average GHG production for a specified service, which, if met or exceeded by a project developer, satisfies the criterion of "additionality." This protocol focuses on the following direct emission reduction activity: avoiding methane emissions from the anaerobic storage and treatment of livestock manure. Therefore, in this case the methane emissions correspond to GHG production, and manure treatment/storage correspond to the specified service.

The analysis to establish the performance standard evaluated U.S.- and California-specific data on dairy and swine manure management systems. Ultimately, it recommended a practice-based/technology-specific GHG emissions performance standard – i.e. the installation of a manure digester (or Biogas Control System (BCS), more generally). The paper was composed of the following sections:

- The livestock industry in the U.S. and California
- Livestock manure management practices
- GHG emissions from livestock manure management
- Data on livestock manure management practices in the U.S. and California
- Current and anticipated regulations in California impacting manure management practices
- Recommendation for a performance threshold for livestock operations
- Considerations for baseline determinations

The initial analysis from that paper can be found in earlier versions of the U.S. Livestock Project Protocol Performance Standard Appendix.[44] In this updated Performance Standard Appendix, The additional, California-specific analysis showed adoption rates similar to the rest of the country, and thus has been removed from this document to reflect the Reserve's decision to apply the same performance standard to all operations across the United States. Beef facility and animal information has also been removed as beef operations are not currently eligible under the Protocol.

[44] Climate Action Reserve U.S. Livestock Project Protocol V1.0-3.0, Appendix C, http://www.climateactionreserve.org/how/protocols/us-livestock/

C.1 Analysis of Common Practice

C.1.1 U.S. Data on Manure Management Practices

For the initial performance standard analysis, data from the Draft EPA Climate Leaders Offset Protocol for Managing Manure with Biogas Recovery Systems (2006) were used to assess national-level manure management practices. That protocol relied on data describing farm distribution and manure management systems from the Manure Management portion of the Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990 – 2004 and used data on the number of farms by farm size and geographic location from the 2002 Census of Agriculture.[45]

Information compiled for the EPA's U.S. GHG Inventory also provided a breakdown of the assumed predominant manure management systems in use for dairy and swine operations. Table C.1 and Table C.3 show data compiled for the systems in place in 2006. Table C.2 and Table C.4 show the Reserve's approximate recreation of the same analysis using the most recently published numbers.[46]

Table C.1. Dairy and Swine Operations in the U.S. by Manure Management System (2006)

Animal	Number of Operations by Manure Management System						
	P/R/P	Anaerobic Digester	Lagoon	Liquid/ Slurry	Solid Storage	Deep Pit	Total
Dairy	72,487	62	4,453	4,345	9,494	1,147	91,989
Swine	53,230	18	6,571	6,303	1,129	11,643	78,894

Source: U.S. EPA Climate Leaders Offset Protocol for Managing Manure with Biogas Recovery Systems (2008), Table I.A.

Table C.2. Dairy and Swine Operations in the U.S. by Manure Management System (2012)

Animal	Number of Operations by Manure Management System						
	P/R/P	Anaerobic Digester	Lagoon	Liquid/ Slurry	Solid Storage	Deep Pit	Total
Dairy	56,075	185*	3,332	3,261	6,263	775	69,890
Swine	55,110	30	5,740	4,641	892	9,029	75,442

Source: U.S. EPA GHG Inventory (2012), U.S. EPA AgSTAR Database (2012), U.S. Dept. of Agriculture, 2007 Census of Agriculture

* There are three systems in operation that digest both swine and dairy manure. For the purpose of this analysis they are considered as dairy.

[45] EPA GHG Inventory Reports in subsequent years (including 2010) still rely on the results of the 2002 Census for this data.

[46] The equivalent analysis based on the 2007 census is unavailable in the same format from the EPA Climate Leaders program. The Reserve performed a similar analysis using data for manure management from the Inventory of U.S. Greenhouse Gas Emissions and Sinks (2012), data on the prevalence of anaerobic digesters from the U.S. EPA's AgSTAR database (Sept. 2012), and data on the number of farms by farms size and geographic location from the 2007 Census of Agriculture, the results of which are Table C.2 and Table C.4. This analysis may not have been performed in precisely the same way as the EPA Climate Leaders Program analysis; however it serves the purpose of evaluating the current state of the dairy and swine manure management practices. The following classification assumptions were made: 1. digester projects associated with farms of size are classified by based on other information in the AgSTAR database, if available, or assumed to be in the medium size class; 2. farms employing anaerobic digesters are subtracted from the USDA counts based on "Baseline System" or other information in the AgSTAR database, if available. Where the "Baseline System" is categorized as "Storage Tank or Pond or Pit," the farm is assumed to belong in the "Liquid/Slurry" category for Dairy and the "Deep Pit" category for Swine.

The distribution of livestock across different sized operations can be an important criterion when developing a livestock manure management performance standard. There is a general relationship between manure management practices and operation size, where larger operations (in terms of livestock numbers) tend to use manure management systems that treat and store waste in liquid form (i.e. flush or scrape/slurry systems), particularly in dairy and swine operations.[47]

Table C.3. Dairy and Swine Operations by Size and Manure Management System (2006)

Animal	Number of Operations by Farm Size and Manure Management System							
	Farm Size	P/R/P	Anaerobic Digester	Lagoon	Liquid/ Slurry	Solid Storage	Deep Pit	Total
Dairy	≥500 head	320	48	1,614	675	245	-	2,902
	200-499	3,213	9	617	652	54	-	4,546
	1-199	6,8954	5	2,223	3,017	9,195	1,147	84,541
Swine	≥2000 head	-	14	2,581	1,084	297	2,774	6,749
	200-2000	-	3	3,990	5,219	832	8,869	18,913
	1-199	53,230	1	-	-	-	-	53,231

Source: U.S. 2002 Census of Agriculture.

Table C.4. Dairy and Swine Operations by Size and Manure Management System (2012)

Animal	Number of Operations by Farm Size and Manure Management System							
	Farm Size	P/R/P	Anaerobic Digester	Lagoon	Liquid/ Slurry	Solid Storage	Deep Pit	Total
Dairy	≥500 head	312	154	1,824	710	284	-	3,284
	200-499	3205	25	502	531	44	-	4,307
	1-199	52559	6	1,006	2,020	5,934	775	62,299
Swine	≥2000 head	-	26	3,182	1,295	358	3,345	8,206
	200-2000	-	3	2,557	3,347	534	5,685	12,125
	1-199	55,110	1	-	-	-	-	55,111

Source: U.S. EPA GHG Inventory (2012), U.S. EPA AgSTAR Database (2012), U.S. Dept. of Agriculture, 2007 Census of Agriculture.

According to the Interim Draft Winter 2006 AgSTAR Digest used for the initial analysis, of 91,988 dairy and 78,894 swine farm operations in the United States, a total of 80 anaerobic digesters were in operation: 62 (0.07%) for dairy manure and 18 (0.02%) for swine manure.

Data were also disaggregated in the Climate Leaders protocol to determine whether digester installation was a common practice in any animal production operation size range. As was shown in Table C.3, even at large animal production operations, very few digester systems were in place. At dairy farms with ≥500 head, only 1.7% of manure management systems included digesters, and of swine farms with >2000 head, only 0.2% had digesters.

[47] U.S. Inventory of Greenhouse Gas Emissions and Sinks: 1990-2004 (and earlier editions), US Environmental Protection Agency, Report # 430-R-06-002, April 2006.

The most current information from the AgSTAR database (September 2012) shows that the number of anaerobic digesters in operation or under construction has nearly tripled at dairy farms and increased by more than 50% at swine farms. In terms of prevalence as a manure management practice across farms however, the practice remains the exception, rather than the rule. Currently there are 185 digesters at dairy farms (0.14%), and 30 at swine farms (0.03%). The number of digesters at the largest farms increased the most significantly, with 154 digesters at dairy farms with ≥500 head (4.69%), and 26 at swine operations with ≥2000 head (0.32%). Of the 185 dairy farms with anaerobic digesters in operation, 84 have participated in GHG offset programs; eight of the 30 swine farms with anaerobic digester have participated in GHG offset programs. Table C.5 shows the distribution and percentages of digesters in operation or under construction by size farm, compared to farms with other manure management practices; Table C.6 shows the same distribution, but does not include the digesters at farms participating in GHG offset programs.

The "natural" market penetration of anaerobic digesters on livestock facilities can be considered as the percentage of farms that choose this management option without the incentive provided by GHG offset programs. Table C.6 shows that the natural market penetration of anaerobic digesters on dairy and swine facilities in the U.S. remains very low. The highest rate of adoption is among dairy farms with ≥500 head, at 2.31%. However, this number conservatively includes anaerobic digestion facilities that are currently under construction. As many if not all of these facilities may actually be installed in response to GHG offset programs (which is often not known until they are operational and become publicly listed in one of these programs), even this small rate of adoption is likely to be overestimated by this analysis. If the anaerobic digesters that are under construction are all assumed to be GHG offset projects, then the natural market penetration of anaerobic digesters on dairy facilities of ≥ 500 head drops to 1.71%.

Table C.5. Dairy and Swine Operations by Size and Manure Management System (2012)

Animal	Number of Operations by Farm Size and Manure Management System							
	Farm Size	P/R/P	Anaerobic Digester	Lagoon	Liquid/ Slurry	Solid Storage	Deep Pit	Total
Dairy	≥500 head	312 9.49%	154 4.69%	1,824 55.53%	710 21.63%	284 8.66%	- -	3,284
	200-499	3,205 74.41%	25 0.58%	502 11.66%	531 12.32%	44 1.03%	- -	4,307
	1-199	52,559 84.37%	6 0.01%	1,006 1.61%	2,020 3.24%	5,934 9.52%	775 1.24%	62,299
	Total	56,075 80.23%	185 0.26%	3,332 4.77%	3,261 4.67%	6,263 8.96%	775 1.11%	69,890
Swine	≥2000 head	- -	26 0.32%	3,182 38.78%	1,295 15.78%	358 4.37%	3,345 40.76%	8,206
	200-1999	- -	3 0.02%	2,557 21.09%	3,347 27.60%	534 4.40%	5,685 46.88%	12,125
	1-199	55,110 99.998%	1 0.002%	- -	- -	- -	- -	55,111
	Total	55,110 73.05%	30 0.04%	5,740 7.61%	4,641 6.15%	892 1.18%	9,029 11.97%	75,442

Source: U.S. EPA GHG Inventory (2012), U.S. EPA AgSTAR Database (2012), U.S. Dept. of Agriculture, 2007 Census of Agriculture.

Table C.6. Dairy and Swine Operations by Size and Manure Management System (2012) Not including those participating in a GHG offset program.

Animal	Number of Operations by Farm Size and Manure Management System							
	Farm Size	P/R/P	Anaerobic Digester	Lagoon	Liquid/ Slurry	Solid Storage	Deep Pit	Total
Dairy	≥500 head	312 *9.73%*	74 *2.31%*	1,824 *56.91%*	710 *22.17%*	284 *8.88%*	- -	3,204
	200-499	3,205 *74.47%*	21 *0.49%*	502 *11.67%*	531 *12.33%*	44 *1.03%*	- -	4,303
	1-199	52,559 *84.37%*	6 *0.01%*	1,006 *1.61%*	2,020 *3.24%*	5,934 *9.52%*	775 *1.24%*	62,299
	Total	56,075 *80.33%*	101 *0.14%*	3,332 *4.77%*	3,261 *4.67%*	6,263 *8.97%*	775 *1.11%*	69,806
Swine	≥2000 head	- -	19 *0.23%*	3,182 *38.81%*	1,295 *15.79%*	358 *4.37%*	3,345 *40.80%*	8,199
	200-1999	- -	2 *0.02%*	2,557 *21.09%*	3,347 *27.60%*	534 *4.40%*	5,685 *46.89%*	12,124
	1-199	55,110 *99.998%*	1 *0.002%*	- -	- -	- -	- -	55,111
	Total	55,110 *73.06%*	22 *0.03%*	5,740 *7.61%*	4,641 *6.15%*	892 *1.18%*	9,029 *11.97%*	75,434

Source: U.S. EPA GHG Inventory (2012), U.S. EPA AgSTAR Database (2012), U.S. Dept. of Agriculture, 2007 Census of Agriculture, open GHG offset program registries.

Finally, as anaerobic digesters are most likely to be installed on livestock facilities that already utilize liquid-based manure management systems, it is useful to examine the market penetration among only these facilities. Table C.7 shows that, among the total facilities utilizing liquid manure management systems, the natural market penetration of anaerobic digesters is 1.35% for dairy farms and 0.11% for swine farms.[48] The highest rate, seen among dairy farms of ≥500 head, is 2.84%. This continues to be an extremely low rate of adoption for anaerobic digestion technology.

[48] There is seemingly 100% market penetration on swine farms with <200 animals, due to the fact that there was only one farm in the dataset utilizing liquid manure management, and it also had an anaerobic digester. A greater trend of adoption of anaerobic digestion cannot be drawn from this single farm.

Table C.7. Dairy and Swine Operations Utilizing Liquid Manure Management, by Size and Manure Management System (2012)
Not including those participating in a GHG offset program.

Animal	Number of Operations by Farm Size Using Anaerobic Manure Management (Excluding GHG Offsets)			
	Farm Size	Anaerobic Digester	Liquid Manure Management	Total
Dairy	≥500 head	74 *2.84%*	2,534 *97.16%*	2,608
	200-499	21 *1.99%*	1,033 *98.01%*	1,054
	1-199	6 *0.16%*	3,800 *99.84%*	3,806
	Total	101 *1.35%*	7,367 *98.65%*	7,468
Swine	≥2000 head	19 *0.24%*	7,822 *99.76%*	7,841
	200-1999	2 *0.02%*	11,589 *99.98%*	11,591
	1-199	1 *100.00%*	- -	1
	Total	22 *0.11%*	19,410 *99.89%*	19,432

C.1.2 U.S. and State Manure Management Regulations

As a part of the Reserve's protocol management, regulatory developments are tracked through, among other outreach and research activities, reporting on regulatory requirements by project developers and verification bodies in the verification process. Of the farms with an anaerobic digester that have participated in GHG offset projects documented in EPA's AgSTAR program, 65 have listed their projects under the Reserve's U.S. Livestock Project Protocol. Twenty-seven projects have been registered with the Reserve, i.e., successfully undergone the verification process. This includes projects in four of the five top dairy producing states, namely, California, Wisconsin, Texas and Idaho. In states where registered Reserve projects are located, no state or federal regulations have been found that would require the use of a BCS.

C.2 Performance Standard Recommendation

The original SAIC report recommended that a performance standard apply to the control of methane emissions from dairy and swine livestock operations in the U.S. and California. In particular, the performance standard should be a technology-specific threshold that dairy or swine operators would meet. The recommended threshold would be the installation of a BCS (e.g. an anaerobic digester).

The report found that even under favorable conditions digesters were found on less than 1% of the dairies in California, which was found to be representative of the U.S. market; and that if a dairy operator chose to install a digester then the farmer would be managing waste in the 99th percentile. This constitutes above and beyond common practice. The report also found that the main barrier inhibiting the installation and use of digesters was cost. Cost studies performed by EPA's AgSTAR program and the California Electricity Commission indicated that significant subsidies and/or incentives were needed to encourage additional digester installations.

The Reserve adopted this performance standard recommendation based on the data available at the time of the SAIC report. While the number of anaerobic digesters has increased significantly, the market penetration of BCS technology remains quite low, especially among those farms which are not receiving revenues from GHG offset markets. Today a dairy operator who chooses to install a digester would be managing waste in the 98th percentile—a modest increase since the original analysis, but hardly a significant shift in common practice. Furthermore, cost continues to inhibit wider adoption of BCS technologies according to a recent EPA report on the status of anaerobic digester adoption.[49] In light of these facts, the Reserve will not alter the current performance standard, but will continue to monitor market developments in the future.

C.3 Renewable Energy Credits and Other Revenue Opportunities for Biogas-to-Energy Projects

Along with carbon credits, there are opportunities for farms installing digesters to earn additional revenues from a variety of sources that support renewable energy generation. These include loans and grants for developing biogas-to-energy projects and the sale of Renewable Energy Certificates (RECs) for use in a renewable portfolio standard (RPS) or a renewable portfolio goal (RPG)[50].

When considering additionality and the ability to generate RECs and CRTs from a livestock project, it is important to remember that the REC and CRT are created by two different but related activities. The REC is awarded for generating renewable electricity from the biogas collected by the BCS, whereas the CRT is awarded for the climate benefit created by the conversion of CH_4 in the biogas into CO_2 through combustion of the biogas. Under this protocol, projects are not required to generate electricity with collected biogas or send it to a natural gas pipeline. Rather, they are only required to destroy the biogas. So while a project may generate renewable electricity with its biogas, renewable energy generation is not an activity required or credited under this protocol.

As there are a number of active RPS, RPG and voluntary REC programs nationwide, the availability of revenue from the sales of RECs is inherently represented in the data analyzed to set the performance standard. Since this analysis shows that the installation of a digester is not common practice at dairy and swine farms, the Reserve does not limit a project's ability to generate or sell RECs. Due to the numerous barriers to implementation of an anaerobic digester project, their success typically relies on a complex array of factors, including multiple incentive program. Renewable energy incentives alone have not significantly increased the natural market penetration of these projects.

When considering additionality and the availability of public dollars to support the development of biogas-to-energy projects, the Reserve has identified numerous state and local programs to support such projects through grants, loans and payments. Although the Reserve's performance standard tests do not require individual project assessments of financial viability or returns, they are designed to reflect these factors in determining which projects are additional. Even with the funds available, the installation of anaerobic digesters according to this protocol is still very rare. Thus, even if a project does receive a grant or loan to support the generation of renewable

[49] U.S. Anaerobic Digester Status Report, October 2010, http://www.epa.gov/agstar/documents/digester_status_report2010.pdf

[50] Whereas compliance with an RPS is mandatory, RPGs set voluntary compliance targets.

energy from a biogas project, the performance standard and rules set forth in this protocol should ensure the additionality of the CRTs generated.

Beyond grants and loans for biogas-to-energy projects, there are two nationwide payment programs administered by USDA Natural Resource Conservation Service (NRCS) that support the installation of anaerobic digesters. Authorized by the 2008 Farm Bill, the Environmental Quality Incentives Program (EQIP), and the Chesapeake Bay Watershed Initiative (CBWI) are programs that provide payments to support the installation of a BCS and are implemented at the state- and county-level. NRCS expressly allows the sale of environmental credits from enrolled lands,[51] but does not provide any additional guidance on ensuring the environmental benefit of any mitigation payment stacked with an NRCS payment.

All NRCS programs share a common set of conservation practice standards that contain information on why and where the practice is to be applied, and set forth the minimum quality criteria that must be met during the application of that practice in order for it to achieve its intended purpose(s).

NRCS Conservation Practice Standard 366 – *Anaerobic Digester* (CPS 366) provides assistance to farmers for the treatment of manure and other byproducts of animal agricultural operations for one or more of the following reasons: to capture biogas for energy production, to manage odors, to reduce the net effect of greenhouse gas emissions, or to reduce pathogens.[52]

Data obtained from NRCS show that less than 0.3% of farms eligible for funding under CPS 366 (i.e., farms with anaerobic operations) have received NRCS funds to install a BCS.[53] In practice, only 9% of the farms that installed BCS since 2004 have received NRCS funds. Because the installation of anaerobic digesters is expensive, uncommon and generally not already funded by NRCS programs, the use of NRCS payments to help finance project activity is allowed under this protocol.

[51] EQIP, 7 CFR §1466.36; CSP, 7 CFR §1470.37.
[52] Natural Resources Conservation Service. (September 2009). Conservation Practice Standard, Anaerobic Digester, Code 366. State-specific conservation practice standards can be downloaded from http://efotg.sc.egov.usda.gov//efotg_locator.aspx.
[53] Based on 2004-2011 data obtained from NRCS Resource Economics, Analysis and Policy Division through personal communication.

Appendix D Data Substitution

This appendix provides guidance on calculating emission reductions when data integrity has been compromised either due to missing data points or a failed calibration. No data substitution is permissible for the operational status of destruction devices. Rather, the methodologies presented below are to be used only for the methane concentration and flow metering parameters. If operational data are missing for a destruction device, then the device shall be assumed to have been inoperable, and will be assigned a destruction efficiency of zero for that period.

D.1 Missing Data

The Reserve expects that projects will have continuous, uninterrupted data for the entire verification period. However, the Reserve recognizes that unexpected events or occurrences may result in brief data gaps.

The following data substitution methodology may be used only for flow and methane concentration data gaps that are discrete, limited, non-chronic, and due to unforeseen circumstances. Data substitution can only be applied to methane concentration *or* flow readings, but not both simultaneously. If data are missing for both parameters, no reductions can be credited.

Further, substitution may only occur when the following is true:

1. For methane concentration substitution, flow rates during the data gap must be consistent with normal operation.
2. For flow substitution, methane concentration rates during the data gap must be consistent with normal operations.

If corroborating parameters fail to demonstrate any of these requirements, no substitution may be employed. If the requirements above can be met, the following substitution methodology maybe applied:

Duration of Missing Data	Substitution Methodology
Less than six hours	Use the average of the four hours immediately before and following the outage
Six to 24 hours	Use the 90% lower or upper confidence limit of the 24 hours prior to and after the outage, whichever results in greater conservativeness
One to seven days	Use the 95% lower or upper confidence limit of the 72 hours prior to and after the outage, whichever results in greater conservativeness
Greater than one week	No data may be substituted and no credits may be generated

Note: It is conservative to use the upper confidence limit when calculating emissions from the BCS (Equation 5.6); however it is conservative to use the lower confidence limit when calculating the total amount of methane that is destroyed in the BCS Equation 5.10.

For periods when it is not possible to use data substitution to fill data gaps, no emission reductions may be claimed. The methane flow volume for these days shall be zero, and the number of reporting days for that month shall be reduced to exclude the days of missing data. This guidance is not to be used for venting events.

Appendix E Development of the B_0 Sampling and Analysis Methodology

With the release of Livestock Protocol Version 4.0, the Reserve has adopted a novel methodology for the sampling and analysis of livestock manure to determine maximum methane potential. In all previous versions of the protocol, the value of this term was defined by the default options provided in Table B.3, which were themselves sourced from the EPA Climate Leaders Draft Manure Offset Protocol. Other than a change in the value of the default for Dairy Cows with Version 2.1 from a “low roughage” value to a “high roughage” value, these default values have not changed since the first version of the protocol was adopted. Reserve staff have received feedback from stakeholders that in many cases, the default value for a particular animal category, especially Dairy Cows, is excessively conservative. Based on this feedback, the Reserve initiated a process to explore the options for updating the default values for maximum methane potential (B_0). After review of existing methodologies and literature related to manure methane potential, the Reserve determined that there is currently not a clear basis for establishing different default values. However, direct sampling and analysis were identified as an option that could be immediately provided as an alternative to the existing default values.

In 2009 the Reserve adopted the Organic Waste Digestion project protocol (updated to Version 2.0 in 2011). This protocol introduced a procedure for the determination of site-specific B_0 value for organic wastewater streams (OWD V2.0, Section 6.1.3.2). These requirements formed the basis for the development of a sampling and analysis procedure for livestock projects.

In early September, 2012, the Reserve solicited stakeholder interest for participation in the development process for this new methodology. A diverse group of 36 stakeholders representing carbon project developers, academia, government, livestock industry, GHG verification bodies, and others, responded to this request. These stakeholders then received a memorandum detailing the proposed methodology and were invited to a webinar on September 19, 2012 to provide feedback and engage in discussion. 22 individuals participated in the webinar discussion, providing a great deal of feedback and suggestions for improvement.

In addition to the public stakeholder consultation, Reserve staff worked directly with experts in industry and academia to further refine the methodology. The goal was to identify a sampling and testing regime that could consistently provide accurate estimates of the B_0 value of different manure streams, and that would be reasonably practical for implementation. The major considerations and decisions are addressed below.

Sampling Schedule

The sampling procedure requires that six samples be taken at regular intervals throughout the day. These individual samples are then combined into one composite sample to represent that event. The sampling procedure in the OWD protocol calls for 10 samples spaced out over at least one week. In consultation with expert stakeholders, it was determined that livestock manure will be less variable over such short timescales, and that the collection of multiple samples in a single day would be sufficient to control for sample variability and error. A more onerous sampling requirement would introduce additional resourcing requirements and costs disproportionate to any reduction in uncertainty/error.

The procedure also requires that the sampling event take place between the months of August through November (inclusive). The Reserve has limited the applicability of this procedure to dairy facilities, and expects that it will mainly be used for the determination of a site-specific B_0

for dairy cows. Thus, the timing of the sampling procedure is designed to avoid overestimating the B_0 value for this particular livestock category. Academic experts advised the Reserve that the methane generating potential of dairy cow manure tends to be positively correlated with milk production.[54] To ensure that the average B_0 value for the year is not overestimated, it is appropriate to avoid sampling the manure during periods of above-average milk production. Reserve staff used data from the National Agricultural Statistics Service[55] to examine monthly milk production trends. For the years 1998-2011, the milk production for each month (in lb/head) was compared to the average monthly milk production for that year. This process highlighted the months with above or below-average milk production, while controlling for the overall trend of increasing milk production year-over-year. Figure E.1 shows the results of this analysis and the consistent pattern of milk production during this 14 year period.

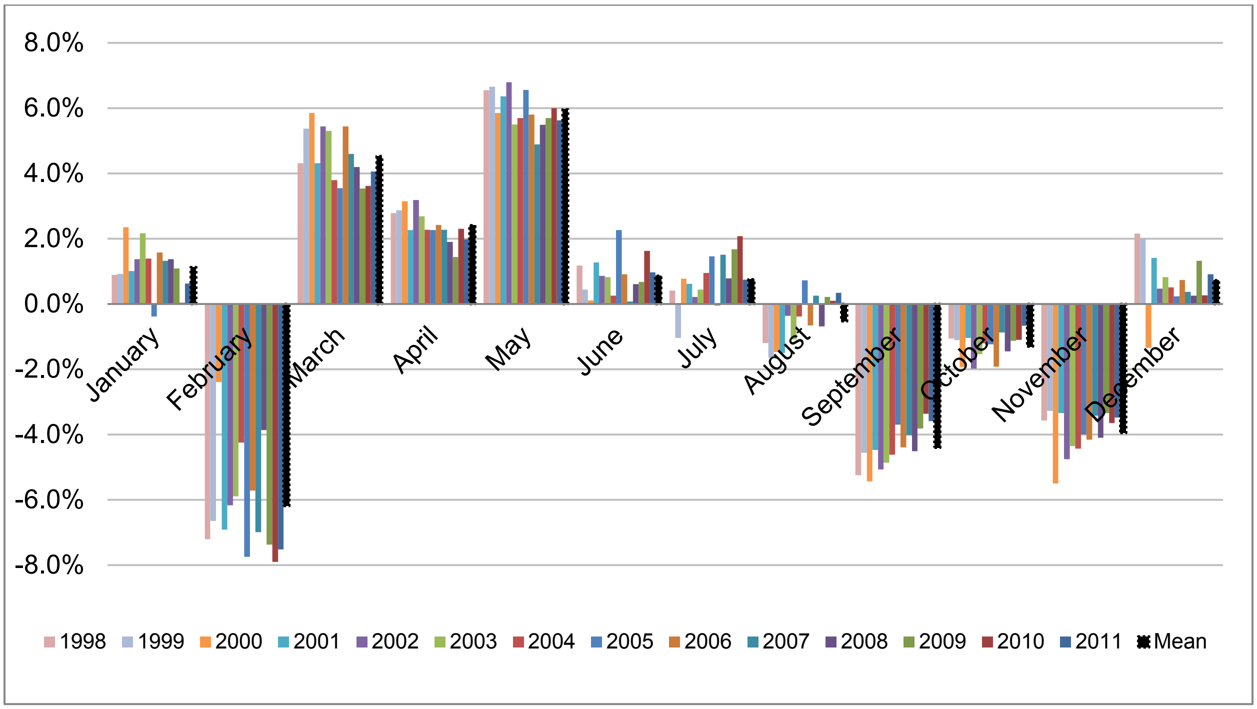


Figure E.1. Monthly Milk Production Trends as a Percent Change Over Annual Average Monthly Milk Production (1998-2011)

Based on this analysis the Reserve has limited the sampling period to August through November. These months consistently exhibit average- to below-average milk production, which should result in a conservative estimate of the annual average B_0 value.

Sample Source

The procedure instructs the user to obtain a manure sample that represents only a single animal category, prior to mixing with other residues (except for flush water in the case of flush systems). While certain stakeholders indicated through public comment that they would prefer to sample the entire waste stream as it enters the digester, there are two main reasons why this requirement was not amended:

[54] In the future, it may be possible to develop a default methane potential that is based directly on monthly milk production, though additional research is needed.
[55] Accessed from the USDA website at http://quickstats.nass.usda.gov/.

1. The waste stream entering the digester may contain ineligible materials which, while permitted to be processed by the project BCS, should not be represented in the quantification of baseline emissions.
2. The baseline quantification model is run on a monthly basis, using the actual animal population figures for that month. The relative populations of different animal categories may change during the year, resulting in an overall B_0 value for the manure from that facility that is variable through time. To use a composite B_0 value, representative of multiple animal categories, would create quantification inaccuracies if relative populations change from one month to the next (see Table E.1).

Table E.1. Effects of Relative Population Size on Composite B_0 Value

Animal Category	B_0 Value	Population in Month 1	Population in Month 2	Population in Month 3
Dairy Cows	0.24	2,000	800	3,000
Heifers	0.17	500	2,000	200
Calves	0.17	500	1,200	0
	Composite B_0 Value	***0.22***	***0.18***	***0.24***

There is an additional step for dairies that utilize a flush system for manure management, as the flush water is typically composed of some type of wastewater, which could have a significant methane potential. For these systems it is necessary to also sample the flush water inlet point prior to mixing with the manure, so that the methane potential of the flush water can then be subtracted from the methane potential of the sample.

Laboratory Analysis

The Reserve undertook research to determine whether standard procedures/processes existed for the professional analysis of B_0 potential. This research revealed that while there is currently no standard laboratory certification scheme within the US pertaining to this type of analysis, there are commonly-accepted methods for undertaking the relevant biochemical methane potential (BMP) analysis itself. The requirements to document a laboratory's experience and standard operating procedures were introduced to ensure rigor and consistency among testing bodies.

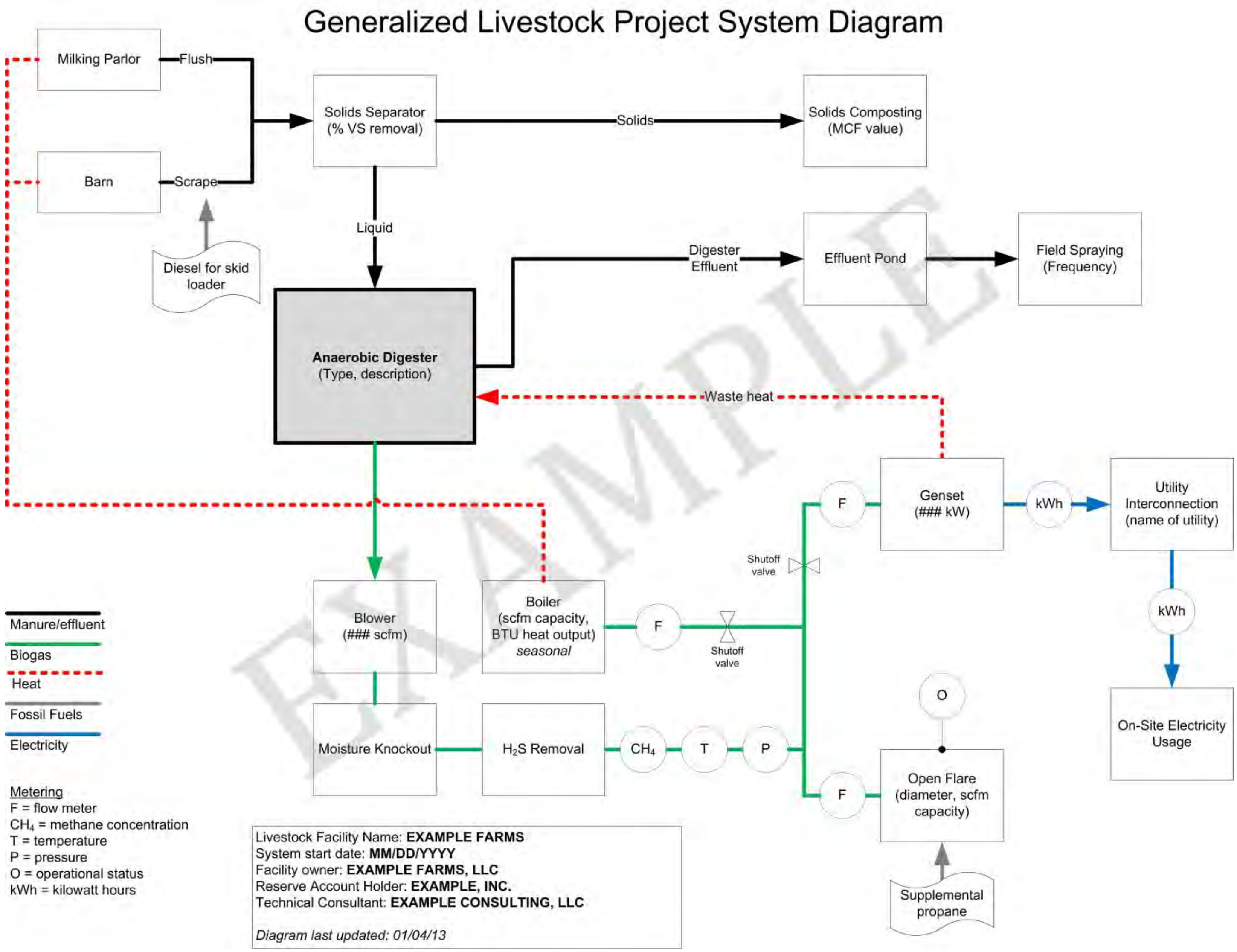
The Reserve consulted with commercial and university testing laboratories regarding the requirements for the biochemical methane potential (BMP) assay. The resulting requirements closely resemble the standard procedures of existing laboratories. It is necessary for the protocol to prescribe at least basic parameters for the BMP assay in order to ensure consistency among projects that hire different laboratories. The inclusion of a control assay was suggested by multiple laboratories as an important quality check on the viability of the seed inoculum that is used for the BMP assay.

Stakeholder Participation

The Reserve would like to thank the following stakeholders, in addition to others not listed here, for their participation in the research and development of this methodology.

David Belcher	Camco
Michael Carim	First Environment, Inc.
Dr. Craig Frear	Washington State University
Noel Gurwick	Smithsonian Environmental Research Center
Karen Haugen-Kozyra	The Prasino Group
Cortney Itle	Eastern Research Group, Inc.
Dr. Xiaomei Li	XY Green Carbon
Dr. John H. Martin, Jr.	Hall Associates
Carl Morris	Joseph Gallo Farms
Dr. Scott Subler	Environmental Credit Corp.
Peter Weisberg	The Climate Trust

Appendix F Sample Livestock Project Diagram



CAPCOA GHG Rx Protocol:

Revised Compliance Offset Protocol Livestock Projects

(Based on the Revised Compliance Offset Protocol Livestock Projects Adopted on November 14, 2014 by the California Air Resources Board)

(Approved by the CAPCOA Board on December 10, 2014)

The following conditions apply for use in the CAPCOA GHG Rx:

1. **Approve protocol only for projects that occur within California.**

California Environmental Protection Agency

AIR RESOURCES BOARD

Compliance Offset Protocol Livestock Projects

Capturing and Destroying Methane from Manure Management Systems

Adopted: November 14, 2014

Note: *All text is new. As permitted by title 2, California Code of Regulations, section 8, for ease of review, underline to indicate adoption has been omitted.*

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Chapter 1. Purpose and Definitions

1.1. Purpose

(a) The purpose of the Compliance Offset Protocol Livestock Projects (protocol) is to quantify greenhouse gas emission reductions associated with the installation of a BCS for manure management on dairy cattle and swine farms that would otherwise be vented into the atmosphere as a result of livestock operations from those farms.

(b) AB 32 exempts quantification methodologies from the Administrative Procedure Act[1]; however, those elements of the protocol are still regulatory. The exemption allows future updates to the quantification methodologies to be made through a public review and Board adoption process but without the need for rulemaking documents. Each protocol identifies sections that are considered quantification and exempt from APA requirements. Any changes to the non-quantification elements of the offset protocols would be considered a regulatory update subject to the full regulatory development process. Those sections that are considered to be a quantification methodology are clearly indicated in the title of the chapter or subchapter if only a portion of that chapter is considered part of the quantification methodology of the protocol.

1.2. Definitions

(a) For the purposes of this protocol, the following definitions apply:

(1) “Aerobic Treatment” means the biological oxidation of manure collected as a liquid with either forced or natural aeration. Natural aeration is limited to aerobic and facultative ponds and wetland systems and is due primarily to photosynthesis. Hence, these systems typically become anoxic during periods without sunlight.

(2) “Anaerobic” means pertaining to or caused by the absence of oxygen.

(3) “Anaerobic Digester” or “Digester” means a large containment vessel or covered lagoon that collects and anaerobically digests animal excreta with or without straw. Digesters are designed and operated for waste

[1] Health and Safety Code section 38571

stabilization by the microbial reduction of complex organic compounds to CO_2 and CH_4, which is captured and flared or used as a fuel.

(4) “Baseline Emissions,” see “Project Baseline Emissions”

(5) “Biogas Control System” or “BCS” commonly referred to as a digester, is a system that is designed to capture and destroy the biogas that is produced by the anaerobic treatment and/or storage of livestock manure and/or other organic material.

(6) “Biogenic CO_2 Emissions,” for the purposes of this protocol, means CO_2 emissions resulting from the combustion and/or aerobic decomposition of organic matter. Biogenic emissions are considered to be a natural part of the carbon cycle, as opposed to anthropogenic emissions.

(7) “Burned for Fuel” means the dung and urine that are excreted on fields. The sun dried dung cakes are burned for fuel.

(8) “Cap-and-Trade Regulation” or “Regulation” means ARB’s regulation establishing the California Cap on Greenhouse Gas Emissions and Market-Based Compliance Mechanisms set forth in title 17, California Code of Regulations Chapter 1, Subchapter 10, article 5 (commencing with section 95800).

(9) “Cattle and Swine Deep Bedding” means that as manure accumulates, bedding is continually added to absorb moisture over a production cycle and possibly for as long as 6 to 12 months. This manure management system is also known as a “bedded pack manure” management system and may be combined with a dry lot or pasture.

(10) “Centralized Digester” means a digester that integrates waste from more than one livestock operation.

(11) “Composting – Intensive Windrow” means composting in windrows with regular (at least daily) turning for mixing and aeration.

(12) “Composting – In-Vessel” means composting, typically in an enclosed channel, with forced aeration and continuous mixing.

(13) “Composting – Passive Windrow” means composting in windrows with infrequent turning for mixing and aeration.

(14) “Composting – Static Pile” means composting in piles with forced aeration but no mixing.

(15) “Daily Spread” means manure that is routinely removed from a confinement facility and is applied to cropland or pasture within 24 hours of excretion.

(16) “Dry Lot” means a paved or unpaved open confinement area without any significant vegetative cover where accumulating manure may be removed periodically.

(17) “Emission Factor” has the same definition as provided in section 95102 of the Mandatory Reporting Regulation.

(18) “Enclosed Vessel” means a complete mix, fixed film, or plug-flow digester that is topped by a cover (e.g. hardened or dual membrane flexible) that provides a complete enclosure to the digester itself. A digester cover design that does not meet this exact definition must offer verifiable proof that it achieves the same biogas capture efficiency as an enclosed vessel cover would.

(19) “Flare” has the same definition as provided in section 95102 of the Mandatory Reporting Regulation.

(20) “Greenfield Livestock Project” means a project that is implemented at a new livestock facility that has no prior manure management system.

(21) “Initial Start-up Period” means the period between post-system installation and pre-project commencement. After the installation of the project’s BCS, the Offset Project Operator or Authorized Project Designee may run, tune, and test the system to ensure its operational quality.

(22) “Liquid Slurry” means manure that is stored as excreted or with some minimal addition of water in either tanks or earthen ponds outside the animal housing, usually for periods of less than one year.

(23) “Livestock Project” means installation of a BCS that, in operation, causes a decrease in GHG emissions from the baseline scenario through destruction of the methane component of biogas.

(24) “Mandatory Reporting Regulation” or “MRR” means ARB’s regulation establishing the Mandatory Reporting of Greenhouse Gas Emissions set

forth in title 17, California Code of Regulations Chapter 1, Subchapter 10, article 2 (commencing with section 95100).

(25) "Mobile Combustion" means emissions from the transportation of materials, products, waste, and employees that result from the combustion of fuels in company owned or controlled mobile combustion sources.

(26) "Pasture/Range/Paddock" means that the manure from pasture and range grazing animals is allowed to lie as deposited, and is not managed.

(27) "Pit Storage Below Animal Confinements" means the collection and storage of manure usually with little or no added water typically below a slatted floor in an enclosed animal confinement facility, usually for periods of less than one year.

(28) "Project Baseline Emissions" or "Baseline Emissions" means the GHG emissions within the Offset Project Boundary that would have occurred if not for the installation of the BCS.

(29) "Registry offset credits" means the offset credits defined in section 95802 of the Regulation and whose issuance is described in section 95980 and section 95980.1 of the Regulation.

(30) "Solid Storage" means the storage of manure, typically for a period of several months, in unconfined piles or stacks. Manure is able to be stacked because there is a sufficient amount of bedding material or loss of moisture by evaporation.

(31) "Standard Conditions" or "Standard Temperature and Pressure" or "STP" means, for the purposes of this protocol, 60 degrees Fahrenheit and 14.7 pounds per square inch absolute.

(32) "Standard Cubic Foot" or "scf" means, for the purposes of this protocol, a measure of quantity of gas equal to a cubic foot of volume at 60 degrees Fahrenheit and 14.7 pounds per square inch (1atm) pressure.

(33) "Stationary Combustion Source" means a stationary source of emissions from the production of electricity, heat, or steam that result from the combustion of fuels in boilers, furnaces, turbines, kilns, and other facility equipment.

(34) “Uncovered Anaerobic Lagoon” means a type of liquid storage system that is designed and operated to combine waste stabilization and storage. Lagoon supernatant is usually used to remove manure from the associated confinement facilities to the lagoon. Anaerobic lagoons are designed with varying lengths of storage, depending on the climate region, the volatile solids loading rate, and other operational factors. The water from the lagoon may be recycled as flush water or used to irrigate and fertilize fields.

(35) “Van’t Hoff-Arrhenius Factor” means the proportion of volatile solids that are biologically available for conversion to methane based on the monthly temperature of the system.

(b) For terms not defined in subchapter 1.2(a) of this protocol, the definitions in section 95802 of the Regulation apply.

(c) Acronyms. For purposes of this protocol, the following acronyms apply:

(1) “AB 32” means The Global Warming Solutions Act of 2006.

(2) “APA” means Administrative Procedure Act.

(3) “ARB” means California Air Resources Board.

(4) “BCS” means biogas control system.

(5) “BDE” means biogas destruction efficiency.

(6) “CH_4” means methane.

(7) “CITSS” means Compliance Instrument Tracking System Service.

(8) “CNG” means condensed natural gas.

(9) “CO_2” means carbon dioxide.

(10) “GHG” means greenhouse gas.

(11) “GWP” means global warming potential.

(12) “ID” means identification.

(13) “IPCC” means Intergovernmental Panel on Climate Change.

(14) “kg” means kilogram.

(15) “lb” means pound.

(16) “LNG” means liquefied natural gas.

(17) “MMBtu” means one million British thermal units.

(18) “MS” means management system.

(19) “mt” means metric ton.

(20) “N_2O” means nitrous oxide.

(21) “NG” means natural gas.

(22) “QA/QC” means quality assurance/quality control.

(23) “R” mean Rankine.

(24) “scf” means standard cubic feet.

(25) “SSR” means GHG sources, GHG sinks, and GHG reservoirs.

(26) “STP” means standard temperature and pressure.

(27) “TAM” means typical average mass.

(28) “VS” means volatile solids.

Chapter 2. Eligible Activities – Quantification Methodology

This protocol defines a set of activities designed to reduce GHG emissions that result from anaerobic manure treatment at dairy cattle and swine farms. Projects that install a BCS that captures and destroys methane gas from anaerobic manure treatment and/or storage facilities on livestock operations are eligible.

2.1. Project Definition

(a) The BCS must destroy methane gas that would otherwise have been emitted to the atmosphere in the absence of the offset project from uncontrolled anaerobic treatment and/or storage of manure.

(b) Captured biogas can be destroyed on-site, transported for off-site use (e.g. through gas distribution or transmission pipeline), or used to power vehicles.

(c) A centralized digester that integrates waste from more than one livestock operation meets the definition of an offset project.

Chapter 3. Eligibility

In addition to the offset project eligibility criteria and the regulatory program requirements set forth in subarticle 13 of the Regulation, livestock offset projects must adhere to the eligibility requirements below:

3.1. General Eligibility Requirements.

(a) Offset projects that use this protocol must:

(1) Involve the installation and operation of a device, or set of devices, associated with the capture and destruction of methane;

(2) Capture methane that would otherwise be emitted to the atmosphere; and

(3) Destroy the captured methane through an eligible end-use management option per subchapter 3.4 of this protocol.

(b) Offset Project Operators or, if applicable, Authorized Project Designees using this protocol must:

(1) Provide the listing information required by section 95975 of the Regulation and subchapter 7.1 of this protocol;

(2) Monitor GHG emission SSRs within the GHG assessment boundary as delineated in chapter 4 pursuant to the requirements of Chapter 6 of this protocol;

(3) Quantify GHG emission reductions pursuant to Chapter 5 of this protocol;

(4) Prepare and submit the Offset Project Data Report for each reporting period that include the information requirements in chapter 7 of this protocol; and

(5) Obtain offset verification services from an ARB-accredited offset verification body in accordance with section 95977 of the Regulation and Chapter 8 of this protocol.

3.2. Location

(a) Only projects located in the United States and United States' territories are eligible under this protocol.

(b) Offset projects situated on the following categories of land are only eligible under this protocol if they meet the requirements of this protocol and the Regulation, including the waiver of sovereign immunity requirements of section 95975(l) of the Regulation:

(1) Land that is owned by, or subject to an ownership or possessory interest of a Tribe;

(2) Land that is "Indian lands" of a Tribe, as defined by 25 U.S.C. §81(a)(1); or

(3) Land that is owned by any person, entity, or Tribe, within the external borders of such Indian lands.

3.3. The Offset Project Operator or Authorized Project Designee

(a) The Offset Project Operator or Authorized Project Designee is responsible for project listing, monitoring, reporting, and verification.

(b) The Offset Project Operator or Authorized Project Designee must submit the information required by subarticle 13 of the Regulation and in subchapters 7.1 and 7.2 of this protocol.

(c) The Offset Project Operator must have legal authority to implement the offset project.

3.4. Additionality

Offset projects must meet the additionality requirements of section 95973(a)(2) of the Regulation, as well as the requirements in this protocol. Eligible offsets must be generated by projects that yield surplus GHG reductions that exceed any GHG reductions otherwise required by law or regulation or any GHG reduction that would otherwise occur in a conservative business-as-usual scenario. These requirements are assessed through the Legal Requirement Test in subchapter 3.4.1. and the Performance Standard Evaluation in subchapter 3.4.2. of this protocol.

3.4.1. Legal Requirement Test

(a) Emission reductions achieved by a livestock project must exceed those required by any law, regulation, or legally binding mandate, as required by sections 95973(a)(2)(A) and 95975(n) of the Regulation.

(b) The following legal requirement test applies to all livestock projects:

   (1) If no law, regulation, or legally binding mandate requiring the destruction of methane at which the project is located exists, all emission reductions resulting from the capture and destruction of methane are considered to not be legally required, and therefore eligible for crediting under this protocol.

   (2) If any law, regulation, or legally binding mandate requiring the destruction of methane at which the project is located exists, only emission reductions resulting from the capture and destruction of methane that are in excess of what is required to comply with those laws, regulations, and/or legally binding mandates are eligible for crediting under this protocol.

3.4.2. Performance Standard Evaluation

(a) Emission reductions achieved by a livestock project must exceed those likely to occur in a conservative business-as-usual scenario.

(b) The performance standard evaluation for existing farms is satisfied if the depth of the anaerobic lagoons or ponds prior to the offset project's commencement were sufficient to prevent algal oxygen production and create an oxygen-free bottom layer; which means at least 1 meter in depth at the shallowest area.

(c) The performance standard evaluation for a greenfield livestock project is satisfied only if uncontrolled anaerobic storage and/or treatment of manure is common practice in the industry and geographic region where the offset project is located as determined by ARB. Greenfield projects must use the baseline assumptions in Table A.10.

3.5. Offset Project Commencement

(a) For this protocol, offset project commencement is defined as the date at which the offset project's BCS becomes operational.

(b) A BCS is considered operational on the date at which the system begins producing and destroying methane gas upon completion of an initial start-up period. An initial start-up period must not exceed nine months. The commencement date, which follows the initial start-up period, is defined as the date that the BCS becomes operational.

(c) Pursuant to section 95973(a)(2)(B) of the Regulation, compliance offset projects must have an offset project commencement date after December 31, 2006.

3.6. Offset Project Crediting Period

(a) For this protocol, the crediting period for an eligible project is ten reporting periods from the first day of the first reporting period as identified in the first verified Offset Project Data Report received by ARB or an Offset Project Registry approved pursuant to section 95986 of the Regulation.

(b) The upgrade of a BCS at an existing project continues the original crediting period and retains the original baseline scenario.

(c) Switching manure from an existing project to a different BCS, including a centralized BCS, continues the crediting period of the project with the earliest commencement date. For a centralized BCS, only livestock manure that meets the relevant eligibility requirements of chapter 3 of this protocol is eligible for crediting under this protocol.

3.7. Regulatory Compliance

An offset project must meet the regulatory compliance requirements set forth in section 95973(b) of the Regulation.

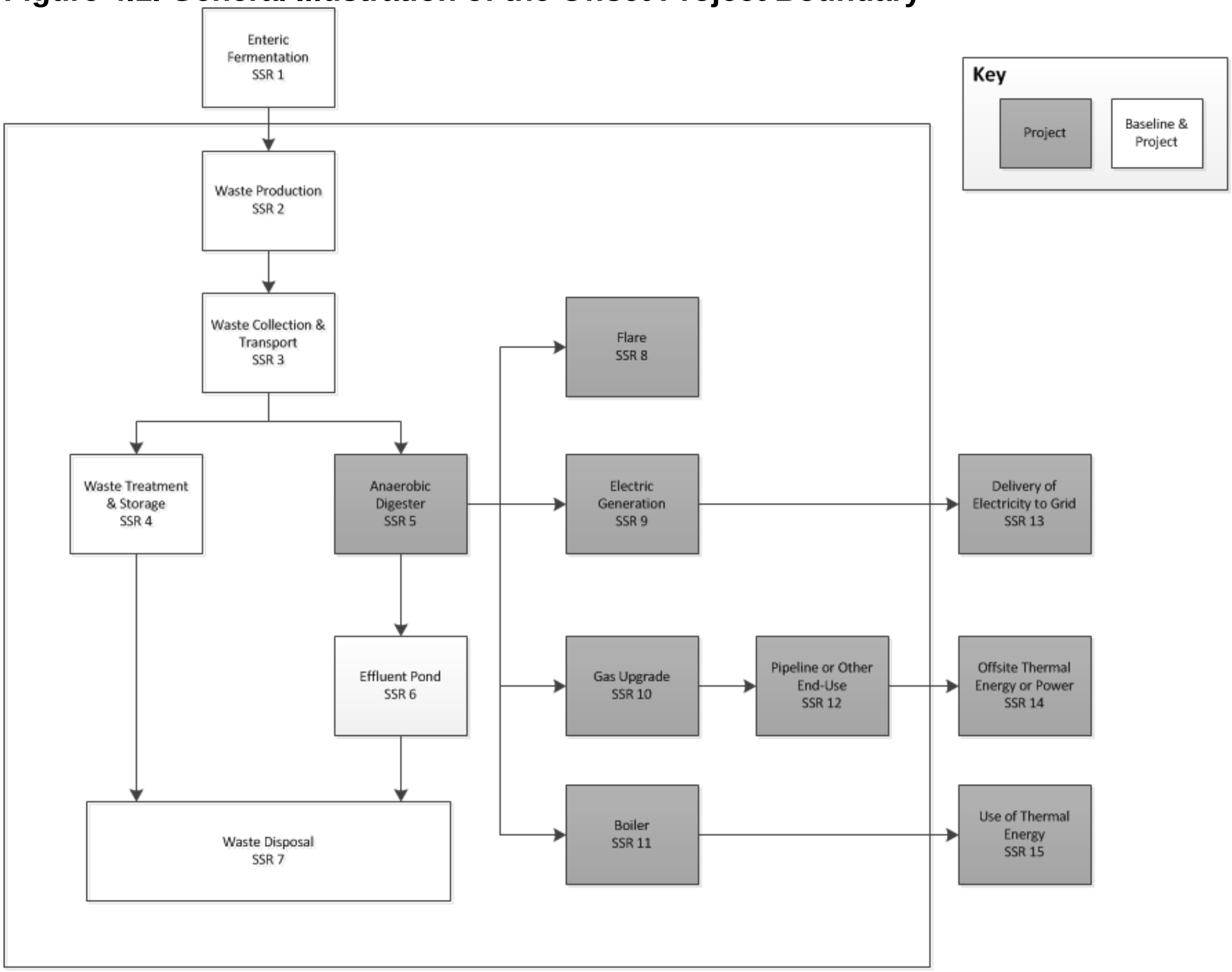
Chapter 4. Offset Project Boundary – Quantification Methodology

The GHG assessment boundary, or offset project boundary, delineates the SSRs that must be included or excluded when quantifying the net change in emissions associated with the installation and operation of a device, or set of devices, associated with the capture and destruction of methane. The following apply to all livestock projects regarding offset project boundaries:

(a) Figure 4.1 illustrates the GHG assessment boundary for livestock projects, indicating which SSRs are included or excluded from the Offset Project Boundary.

- (1) All SSRs within the bold line are included and must be accounted for under this protocol.
- (2) SSRs in unshaded boxes are relevant to the baseline and project emissions.
- (3) SSRs in shaded boxes are relevant only to the project emissions.

Figure 4.1. General Illustration of the Offset Project Boundary



(b) Table 4.1. Description of all GHG Sources, GHG Sinks, and GHG Reservoirslists the SSRs for livestock projects, indicating which gases are included or excluded from the offset project boundary.

Table 4.1. Description of all GHG Sources, GHG Sinks, and GHG Reservoirs

SSR	GHG Source	GHG	Relevant to Baseline (B) or Project (P)	Included/ Excluded
1	Emissions from enteric fermentation	CH_4	B, P	Excluded
2	Emissions from waste deposits in barn, milking parlor, or pasture/corral	N_2O	B, P	Excluded
	Emissions from mobile and stationary support equipment	CO_2	B, P	Included
		CH_4		Excluded
		N_2O		Excluded

SSR	GHG Source	GHG	Relevant to Baseline (B) or Project (P)	Included/ Excluded
3	Emissions from mechanical systems used to collect and transport waste (e.g. engines and pumps for flush systems; vacuums and tractors for scrape systems)	CO_2	B, P	Included
		CH_4		Excluded
		N_2O		Excluded
	Vehicle emissions (e.g. for centralized digesters)	CO_2		Included
		CH_4		Excluded
		N_2O		Excluded
4	Emissions from waste treatment and storage including: anaerobic lagoons, dry lot deposits, compost piles, solid storage piles, manure settling basins, aerobic treatment, storage ponds, etc.	CO_2	B, P	Excluded
		CH_4		Included
		N_2O		Excluded
	Emissions from support equipment	CO_2		Included
		CH_4		Excluded
		N_2O		Excluded
5	Emissions from the anaerobic digester due to biogas collection inefficiencies and venting events	CH_4	P	Included
6	Emissions from the effluent pond	CH_4	B, P	Included
		N_2O		Excluded
7	Emissions from land application	N_2O	B, P	Excluded
	Vehicle emissions for land application and/or off-site transport	CO_2	B, P	Included
		CH_4		Excluded
		N_2O		Excluded
8	Emissions from combustion during flaring, including emissions from incomplete combustion of biogas	CO_2	P	Excluded
		CH_4		Included
		N_2O		Excluded
9	Emissions from combustion during electric generation, including incomplete combustion of biogas	CO_2	P	Excluded
		CH_4		Included
		N_2O		Excluded
10	Emissions from equipment upgrading biogas for pipeline injection or use as CNG/LNG fuel	CO_2	P	Included
		CH_4		Excluded
		N_2O		Excluded
11	Emissions from combustion at boiler including emissions from incomplete combustion of biogas	CO_2	P	Excluded
		CH_4		Included
		N_2O		Excluded
12	Emissions from combustion of biogas by end user of pipeline or CNG/LNG, including incomplete combustion	CO_2	P	Excluded
		CH_4		Included
		N_2O		Excluded

SSR	GHG Source	GHG	Relevant to Baseline (B) or Project (P)	Included/ Excluded
13	Delivery and use of project electricity to grid	CO_2 CH_4 N_2O	P	Excluded
14	Off-site thermal energy or power	CO_2 CH_4 N_2O	P	Excluded
15	Use of project-generated thermal energy	CO_2 CH_4 N_2O	P	Excluded
16	Project construction and decommissioning emissions	CO_2 CH_4 N_2O	P	Excluded

Chapter 5. Quantifying GHG Emission Reductions – Quantification Methodology

(a) GHG emission reductions from a livestock project are quantified by comparing actual project emissions to baseline emissions within the offset project boundary.

(b) The Offset Project Operator or, if applicable, Authorized Project Designee must use the specific calculation methods provided in this protocol to determine baseline and project GHG emissions.

(c) GHG emission reductions must be quantified over an entire reporting period. Pursuant to section 95802(a) of the Regulation, the initial reporting may consist of 6 to 24 consecutive months, and all subsequent reporting periods consist of 12 consecutive months.

(d) Measurements used to quantify emission reductions must be corrected to standard conditions of 60°F and 14.7 pounds per square inch (1 atm).

(e) Global warming potential values must be determined consistent with the definition of Carbon Dioxide Equivalent in MRR section 95102(a).

(f) GHG emission reductions for a reporting period (ER) must be quantified using Equation 5.1 by summing two selections:

(1) The smaller of:

(A) the project methane emission (PE_{CH4}) subtracted from modeled project baseline methane emissions ($BE_{CH4\ Mod}$); or

(B) the metered and destroyed methane ($CH_{4\ meter}$); and

(2) The smaller of:

(A) project carbon dioxide emissions (PE_{CO2}) subtracted from the project baseline carbon dioxide emissions (BE_{CO2}); or

(B) zero.

Equation 5.1: GHG Reductions from Installing a BCS

$$ER = MIN[(BE_{CH4\ Mod}-PE_{CH4}),CH_{4\ meter}] + MIN[(BE_{CO2}-PE_{CO2}),0]$$

Where,			Units
$BE_{CH4\ Mod}$	=	Modeled baseline methane emissions during the reporting period	$mtCO_2e$
PE_{CH4}	=	Total project methane emissions during the reporting period	$mtCO_2e$
$CH_{4\ meter}$	=	Aggregated quantity of methane collected and destroyed during the reporting period	$mtCO_2e$
BE_{CO2}	=	Total baseline anthropogenic CO_2 emissions from electricity consumption and mobile and stationary combustion that would have occurred in the absence of the project	$mtCO_2e$
PE_{CO2}	=	Total project anthropogenic CO_2 emissions from electricity consumption and mobile and stationary combustion sources resulting from project activity	mtCO2e

5.1. Quantifying Baseline Methane Emissions

(a) Total modeled project baseline methane emissions for a reporting period ($BE_{CH4\ Mod}$) must be estimated by using equation 5.2 and summing the baseline methane emissions for all SSRs which table 4.1 identifies as included within the project boundary.

(b) Baseline emissions represent the GHG emission that would have occurred in the absence of the BCS. Baseline emissions are calculated based on the manure management system in place prior to the installation of the BCS. Baseline emissions are recalculated for each reporting period and represent the emissions that would have occurred with the previous manure management system operated under the current conditions.

Equation 5.2: Modeled Project Baseline Methane Emissions

$$BE_{CH4Mod} = \sum_{AS} BE_{CH4,AS} + \sum_{non-AS} BE_{CH4,non-AS}$$

Where,			Units
BE_{CH4}	=	Total project baseline methane emissions for a reporting period.	$mtCO_2e$
$BE_{CH4,AS}$	=	Total project baseline methane emissions from anaerobic storage/treatment systems by livestock category for a reporting period	$mtCO_2e$
$BE_{CH4,non\text{-}AS}$	=	Total project baseline methane emissions from non-anaerobic storage/treatment systems by livestock category for a reporting period	$mtCO_2e$
AS	=	Anaerobic storage/treatment systems	
Non-AS	=	Non-anaerobic storage/treatment systems	

(c) Baseline modeled methane emission from anaerobic storage/treatment systems ($BE_{CH4,AS,L}$) must be quantified using equation 5.3.

(d) Methane producing capacity for each livestock category ($B_{O,L}$) and volatile solids produced (VS_{table}) must use default values from tables A.2 and A.4 as applicable.

(e) The average monthly population for each livestock category ($P_{L,i}$) must use site-specific data monitored and recorded at least monthly.

(f) The fraction of volatile solids ($MS_{AS,L}$) sent to each anaerobic storage/treatment system for each livestock category represents the percent of manure that would be sent to (managed by) the anaerobic manure storage/treatment systems, taking into account any volatile solids removed by solid separation equipment, in the project baseline case, as if the BCS was never installed. Site-specific data must be used if available. If site-specific data is unavailable, values from table A.9 can be used to calculate $MS_{AS,L}$.

(g) The number of reporting days in the reporting month ($RD_{rm,i}$) must be calculated by subtracting the number of days not in the reporting period for the reporting month and the number of days the project is ineligible to report from the total number of reporting days in the reporting month. Ineligible days include, but are not limited to, days with missing data beyond what is allowed to be substituted according to the methods in appendix B.

(h) The annual average live weight of the animals ($Mass_L$), per livestock category, must be taken from site-specific livestock mass data. If site-specific data are unavailable, Typical Average Mass (TAM) values from table A.1 must be used.

(i) The monthly average ambient temperature (T_2) in Kelvin must be obtained from the closest weather station, with available data, located in the same air basin, if applicable.

(j) If the volatile solids retention time in the anaerobic storage/treatment system is less than or equal to 30 days, then the volatile solids retained in the system from the previous month ($VS_{avail, AS, L, i-1}$ - $VS_{deg,AS,L,i-1}$) must be set to zero.

(k) For the month following the complete drainage and cleaning of solid buildup from the anaerobic storage/treatment system, the volatile solids retained in the system from the previous month ($VS_{avail, AS, L, i-1}$ - $VS_{deg,AS,L,i-1}$) must be set to zero.

Equation 5.3: Modeled project baseline methane emissions from anaerobic storage treatment systems

$$BE_{CH4,AS} = \sum_{L,i} (VS_{\deg,AS,L,i} \times B_{0,L}) \times 0.68 \times 0.001 \times GWP_{CH4}$$

Where,			<u>Units</u>
$BE_{CH4,AS}$	=	Total project baseline methane emissions from anaerobic manure storage/treatment systems for a reporting period	$mtCO_2e$
$VS_{deg,AS,L,i}$	=	Monthly volatile solids degraded in anaerobic manure storage/treatment system 'AS' from livestock category 'L'	kg dry matter
$B_{0,L}$	=	Maximum methane producing capacity of manure for livestock category 'L' from table A.2	m^3 CH_4/kg of VS
0.68	=	Density of methane (1 atm, 60°F)	kg/m^3
0.001	=	Conversion factor from kg to mt	
GWP_{CH4}	=	Global warming potential of methane	
L	=	Livestock category	
i	=	Months in the reporting period	

With:

$$VS_{\deg,AS,L,i} = VS_{avail,AS,L,i} \times f$$

Where,			<u>Units</u>
$VS_{deg,AS,L.i}$	=	Monthly volatile solids degraded by anaerobic manure storage/ treatment system 'AS' by livestock category 'L'	kg dry matter
$VS_{avail,AS,L,i}$	=	Monthly volatile solids available for degradation from anaerobic manure storage/treatment system 'AS' by livestock category 'L'	kg dry matter
f	=	Van't Hoff-Arrhenius factor	
i	=	Months in the reporting period	

And:

$$VS_{avail,AS,L,i} = (VS_L \times P_{L,i} \times MS_{AS,L} \times RD_{rm,i} \times 0.8) + (VS_{avail,AS,L,i-1} - VS_{\deg,AS,L,i-1})$$

Where,			Units
$VS_{avail,AS,L}$	=	Monthly volatile solids available for degradation in anaerobic storage/treatment system 'AS' by livestock category 'L'	kg dry matter
VS_L	=	Volatile solids produced by livestock category 'L' on a dry matter basis	kg/ animal/ day
$P_{L,i}$	=	Monthly average population of livestock category 'L'	
$MS_{AS,L}$	=	Fraction of volatile solids sent to (managed in) anaerobic manure storage/treatment system 'AS' from livestock category 'L'	Fraction (0-1)
$RD_{rm,i}$	=	Number of reporting days in the reporting month	days
0.8	=	System calibration factor	
$VS_{avail-1,AS}$	=	Previous month's volatile solids available for degradation in anaerobic system 'AS'	kg
$VS_{deg-1,AS}$	=	Previous month's volatile solids degraded by anaerobic system 'AS'	kg

And:

$$VS_L = VS_{table} \times \frac{Mass_L}{1000}$$

Where,			Units
VS_L	=	Volatile solid excretion on a dry matter weight basis	kg/ animal/ day
VS_{table}	=	Volatile solid excretion from table A.2 or A.4	kg/ day/ 1000kg
$Mass_L$	=	Average live weight for livestock category 'L'; if site-specific data is unavailable, use values from table A.1	kg

And:

$$f = MIN\left(\exp\left[\frac{E\left(T_2 - T_1\right)}{RT_1T_2}\right], 0.95\right)$$

Where,			Units
f	=	Van't Hoff-Arrhenius factor	
E	=	Activation energy constant (15,175)	cal/mol
T_1	=	303.16	Kelvin
T_2	=	Monthly average ambient temperature (K = °C + 273). If $T_2 < 5$ °C then $f = 0.104$.	Kelvin
R	=	Ideal gas constant (1.987)	cal/Kmol

(l) Modeled baseline methane emissions from non-anaerobic storage/treatment systems ($BE_{CH4,non-AS,L}$) must be quantified using equation 5.4.

(m) The fraction of volatile solids ($MS_{non-AS,L}$) sent to each non-anaerobic storage/treatment system for each livestock category represents the fraction of manure that would be sent to (managed by) the non-anaerobic manure storage/treatment systems, taking into account any volatile solids removed by solid separation equipment, in the project baseline case, as if the BCS was never installed. Site-specific data must be used if available. If site-specific data is unavailable, values from table A.9 must be used to calculate $MS_{non\text{-}AS,L}$.

(n) The number of reporting days in the reporting period (RD_{rp}) must be calculated by subtracting the number of days the project is ineligible to report from the total number of reporting days in the reporting period. Ineligible days would include, but are not limited to, days with missing data beyond what is allowed to be substituted according to the methods in appendix B.

(o) The methane conversion factor for the non-anaerobic storage/treatment ($MCF_{non\text{-}AS}$) represents the non-anaerobic systems in place prior to BCS installation and must be obtained from table A.5 for the appropriate system type and average annual temperature (^{o}C).

Equation 5.4: Modeled project baseline methane for non-anaerobic storage/treatment systems

$$BE_{CH4,non-AS} = \sum_{L,i} (P_{L,i} \times MS_{non-AS,L} \times VS_L \times RD_{rm} \times MCF_{non-AS} \times B_{0,L}) \times 0.68 \times 0.001 \times GWP_{CH4}$$

Where,			Units
$BE_{CH4,non\text{-}AS}$	=	Total project baseline methane emissions from non-anaerobic storage/treatment systems for a reporting period, expressed in carbon dioxide equivalent	$mtCO_2e$
P_L	=	Monthly average population of livestock category 'L'	
$MS_{non\text{-}AS,L}$	=	Fraction of volatile solids from livestock category 'L' managed in non-anaerobic storage/treatment systems	Fraction (0-1)
VS_L	=	Volatile solids produced by livestock category 'L' on a dry matter basis	kg/ animal/ day
RD_{rm}	=	Number of reporting days in the current reporting month	days
$MCF_{non\text{-}AS}$	=	Methane conversion factor for non-anaerobic storage/treatment system 'S' from table A.5.	Fraction (0-1)
$B_{0,L}$	=	Maximum methane producing capacity for manure for livestock category 'L' from table A.2	m^3 CH_4/kg of VS dry matter
0.68	=	Density of methane (1 atm, $60^{o}F$)	kg/m^3
0.001	=	Conversion factor from kg to mt	
GWP_{CH4}	=	Global warming potential of methane	
i	=	Months in the reporting period	

With:

$$VS_L = VS_{table} \times \frac{Mass_L}{1000}$$

Where, Units

VS_L	=	Volatile solid excretion on a dry matter weight basis	kg/ animal/ day
VS_{table}	=	Volatile solid excretion from tables A.2 and A.4	kg/ day/ 1000kg
$Mass_L$	=	Average live weight for livestock category 'L'	kg

5.2. Quantifying Project Methane Emissions

(a) Project methane emissions must be quantified for each reporting period.

(b) Project methane emissions for a reporting period (PE_{CH4}) must be quantified by using equation 5.5 and summing the project methane emissions for all SSRs which table 4.1 identifies as included within the project boundary.

Equation 5.5: Project Methane Emissions

$$PE_{CH4} = (PE_{CH4,\ BCS} + PE_{CH4,\ EP} + PE_{CH4,\ non\text{-}BCS}) \times GWP_{CH4}$$

Where, Units

PE_{CH4}	=	Total project methane emissions for the reporting period	$mtCO_2e$
$PE_{CH4,\ BCS}$	=	Methane emissions from the BCS	$mtCH_4$
$PE_{CH4,\ EP}$	=	Methane emissions from the BCS effluent pond	$mtCH_4$
$PE_{CH4,\ non\text{-}BCS}$	=	Methane emissions from sources in the waste treatment and storage category other than the BCS and associated effluent	$mtCH_4$
GWP_{CH4}	=	Global warming potential of methane	

(c) Project methane emissions from the BCS ($PE_{CH4,\ BCS}$) must be quantified using Equation 5.6.

(d) The quarterly methane concentration (C_{CH4}) is used for the entire month in which it is taken and for all subsequent months until a new methane concentration is taken. A weighted average of more frequent samples may also be used.

(e) A site-specific biogas destruction efficiency (BDE_j) of each device must be used when available, and when the destruction device is not listed in table A.6. If a site-specific methane destruction efficiency for devices listed in table A.6 is not available, then the default value from table A.6 must be used. Site-specific methane destruction efficiencies require prior written approval from the Executive Officer.

(f) Biogas flow to an inoperable device must be counted as a separate device with a biogas destruction efficiency (BDE_j) of zero when calculating the fractional monthly weighted average destruction efficiency of devices used during the month ($BDE_{i,weighted}$).

(g) Biogas capture efficiencies (BCE) must be taken from or calculated according to table A.3.

(h) All volume flows (F) must come from the monitored project-specific flow data corrected to standard conditions.

(i) The maximum biogas storage of the BCS system (MS_{BCS}) must be calculated using project-specific information and design documentation.

(j) The number of days for each uncontrolled venting (t_k) must be monitored and recorded at least daily from the time of discovery.

(k) The number of days for each uncontrolled venting (t_k) must date back to the last field check date without any uncontrolled venting events.

Equation 5.6: Project Methane Emissions from the BCS

$$PE_{CH4,BCS} = \sum_i \left[\mathrm{CH}_{4\,\mathrm{meter},i} \times \left((\frac{1}{BCE}) - BDE_{i,weighted} \right) + CH_{4\,vent,i} \right]$$

Where,			Units
$PE_{CH4,\ BCS}$	=	Methane emissions from the BCS	$mtCH_4$
$CH_{4\ meter,i}$	=	Quantity of methane collected and metered in month *i*	$mtCH_4$/ month
BCE	=	Fraction of monthly methane collected by the BCS from table A.3	fraction (0-1)
$BDE_{i,weighted}$	=	Monthly weighted average of all fractional destruction efficiencies of devices used in month *i*.	fraction (0-1)
$CH_{4\ vent,i}$	=	The monthly quantity of methane that is vented to the atmosphere due to BCS venting events	mtCH4/ month
i	=	Months in the reporting period	

With:

$$BDE_{i,weighted} = \frac{\sum_j (F_{j,i} \times BDE_j)}{\sum_j F_{Fj,i}}$$

Where:			Units
j	=	Destruction devices	
Fj,i	=	Volume of biogas in month i sent to destruction device j	scf
BDEj	=	Biogas destruction efficiency of device j	fraction (0-1)

And:

$$CH_{4\ meter,i} = F_i \times C_{CH4} \times 0.0423 \times 0.000454$$

Where,			Units
C_{CH4}	=	Quarterly methane concentration	fraction (0-1)
F_i	=	Volume of biogas from the digester in month i	scf

And:			
$CH_{4\,vent,i} = \sum_k \left((F_{pw,k} \times t_k + MS_{BCS}) \times C_{CH4} \right) \times 0.04230 \times 0.00454$			
Where,			Units
$F_{pw,k}$	=	The average daily biogas production from the digester for the 7 days preceding the venting event k	scf/day
t_k	=	The number of days for each uncontrolled venting event *k* from the BCS system (can be a fraction)	days
MS_{BCS}	=	Maximum biogas storage of the BCS system	scf
C_{CH4}	=	Quarterly methane concentration	fraction (0-1)
0.04230	=	Standard density of methane	lb CH_4/scf CH_4
0.000454	=	Conversion factor from lb to mt	mt/lb

(l) If gas flow metering equipment does not internally correct gas flow volumes to standard conditions, then equation 5.7 must be applied to the volume of biogas prior to calculating project methane emissions from the BCS in equation 5.6.

Equation 5.7: Biogas Volume corrected for Temperature and Pressure

$$F_{corrected,y} = F_{meas,y} \times \frac{519.67}{T_{meas,y}} \times \frac{P_{meas,y}}{1.00}$$

Where:			Units
$F_{corrected,y}$	=	Corrected volume of biogas for time interval y, adjusted to 60 ^oF and 1 atm	scf
$F_{meas,y}$	=	Measured volume of biogas for time interval *y*	cf
$T_{meas,y}$		Measured temperature of the biogas for time interval *y*, $^oR=^oF+459.67$	^oR
Pmeas,y		Measured pressure of the biogas for the time interval *y*	atm

(m) Project methane emissions from the BCS effluent pond ($PE_{CH4,ep}$) must be quantified using equation 5.8.

(n) Methane producing capacity for each livestock category ($B_{O,L}$) and volatile solids produced (VS_{table}) must use default values from tables A.2 and A.4 as applicable.

(o) The number of reporting days in the reporting period (RD_{rp}) must be calculated as the total number of reporting days in the reporting period.

(p) The methane conversion factor for the effluent pond (MCF_{ep}) must be obtained from table A.5 using the liquid/slurry system type and appropriate average annual temperature (^oC).

(q) The fraction of volatile solids ($MS_{L,BCS}$) sent to the BCS for each livestock category represents the fraction of manure that was sent to (managed by) the

BCS, taking into account any volatile solids removed by solid separation equipment. Site-specific data must be used if available. If site-specific data is unavailable, then values from table A.9 must be used to calculate $MS_{L,BCS}$.

(r) The average monthly population ($P_{L,i}$) must use site-specific data monitored and recorded at least monthly.

(s) The number of reporting days in the reporting month ($RD_{rm,i}$) must be calculated by subtracting the number of days not in the reporting period for the reporting month.

(t) The annual average live weight of the animals ($Mass_L$), per livestock category, must be taken from site-specific livestock mass data if the data are available. If site-specific data is unavailable, Typical Average Mass (TAM) values from table A.1 must be used.

Equation 5.8 : Project Methane Emissions from the BCS Effluent Pond(s)

$$PE_{CH4,EP} = \sum_{I} (VS_{ep} \times RD_{rp} \times 0.68 \times MCF_{ep} \times 0.001)$$

Where,			Units
$PE_{CH4,EP}$	=	Methane emissions from the effluent pond	$mtCH_4$
I	=	Number of effluent ponds	
VS_{ep}	=	Volatile solid to effluent pond	kg/day
RD_{rp}	=	Reporting days in the reporting period	days
0.68	=	Density of methane (1 atm, 60^oF)	kg/m^3
MCF_{ep}	=	Methane conversion factor from table A.4	fraction (0-1)
0.001	=	Conversion factor from kg to mt	

With:

$$VS_{ep} = \sum_{L} (VS_L \times P_L \times B_{O,L} \times MS_{L,BCS}) \times 0.3$$

Where,			Units
VS_L	=	VS produced by livestock category 'L' on a dry matter basis.	kg/ animal/ day
P_L	=	Average population of livestock category 'L' (based on monthly population data) for a given reporting period	
$B_{O,L}$	=	Maximum methane producing capacity for livestock category 'L' (of VS dry matter)	m^3CH_4/kg
$MS_{L,BCS}$	=	Fraction of manure from livestock category 'L' that is managed in the BCS	fraction (0-1)
0.3	=	Default value representing the amount of VS that exits the digester as a percentage of the VS entering the digester	

And:

$$P_L = \frac{\sum_i (RD_{rm,i} \times P_{L,i})}{RD_{rp}}$$

Where,			Units
$RD_{rm,i}$	=	Reporting days in the reporting month	days
$P_{L,i}$	=	Monthly average population of livestock category 'L'	
RD_{rp}	=	Reporting days in the reporting period	days

And:

$$VS_L = VS_{table} \times \frac{Mass_L}{1000}$$

Where,			Units
VS_L	=	Volatile solid excretion on a dry matter weight basis	kg/ animal/ day
VS_{table}	=	Volatile solid excretion from tables A.2 and A.4	kg/ day/ 1000kg
$Mass_L$	=	Average live weight for livestock category 'L',	kg

(u) Project methane emissions from manure management system components other than the BCS and the BCS effluent pond ($PE_{CH4,nBCS}$) must be quantified using equation 5.9.

(v) The methane conversion factor for systems other than the BCS and the effluent pond (MCF_S) must be obtained from table A.5 using the appropriate system type and average annual temperature (^oC).

(w) The fraction of volatile solids sent to systems other than the BCS and effluent pond ($MS_{L,S}$) for each livestock category represents the fraction of manure that was sent to (managed by) these systems, taking into account any volatile solids removed by solid separation equipment. Site-specific data must be used if available. If site-specific data is unavailable, values from table A.9 must be used to calculate $MS_{L,S}$.

Equation 5.9: Project Methane Emissions from *Non*-BCS Related Sources

$$PE_{CH4,nBCS} = \left(\sum_L (EF_{CH4,L,nBCSs} \times P_L) \right) \times 0.001$$

Where,			Units
$PE_{CH4,\ nBCS}$	=	Methane from sources in the waste treatment and storage category other than the BCS and associated effluent pond	$mtCH_4$
$EF_{CH4,L,nBCSs}$	=	Emission factor for the livestock population from non-BCS-related sources (nBCSs, calculated below)	$kgCH_4$/ head/ yr
P_L	=	Average population of livestock category 'L' (based on monthly population data) for a given reporting period	
0.001	=	Conversion factor from kg to mt	

$$EF_{CH4,L,nBCSs} = \left(VS_L \times B_{o,L} \times \mathrm{RD}_{\mathrm{rp}} \times 0.68\right) \times \left(\sum_S (MCF_S \times MS_{L,S})\right)$$

Where,			Units
$EF_{CH4,L,nBCS}$	=	Methane emission factor for the livestock population from non-BCS related sources	$kgCH_4$/ head/ yr
VS_L	=	Volatile solids produced by livestock category 'L' on a dry matter basis.	kg/ animal/ day
$B_{o,L}$	=	Maximum methane producing capacity for manure for livestock category 'L' (of VS dry matter) from table A.2	m^3 CH_4/kg
RD_{rp}	=	reporting days in a reporting period	days/yr
0.68	=	Density of methane (1 atm, 60^oF)	kg/m^3
MCF_S	=	Methane conversion factor for system component 'S' from table A.4	fraction (0-1)
$MS_{L,S}$	=	Percent of manure from livestock category L that is managed in non-BCS system component 'S'	fraction (0-1)

And:

$$VS_L = VS_{Table} \times \frac{Mass_L}{1000}$$

Where,			Units
VS_L	=	Volatile solid excretion on a dry matter weight basis	kg/ animal/ day
VS_{Table}	=	Volatile solid excretion from tables A.2 and A.4	kg/ day/ 1000kg
$Mass_L$	=	Average live weight for livestock category 'L',	kg

And:

$$P_L = \frac{\sum_i \left(RD_{rm,i} \times P_{L,i}\right)}{RD_{rp}}$$

Where,			Units
$RD_{rm,i}$	=	Reporting days in the reporting month	days
$P_{L,i}$	=	Monthly average population of livestock category 'L'	
RD_{rp}	=	Reporting days in the reporting period	days

5.3. Metered Methane Destruction Comparison

Offset projects must compare the modeled methane emission reductions for the reporting period, as calculated in equation 5.2 above, with the actual metered amount of methane that is destroyed by the BCS over the same period. The lesser of the two values is to be used as the total methane emission reductions for the reporting period in question.

(a) The total metered methane destruction ($CH_{4\ destroyed}$) must be quantified using equation 5.10.

(b) The quarterly methane concentration (C_{CH4}) is used for the entire month in which it is taken and for all subsequent months until a new methane concentration is taken. A weighted average of more frequent samples may also be used.

(c) All volume flows (F) must come from the monitored project-specific flow data corrected to standard conditions.

(d) A site-specific biogas destruction efficiency (BDE_j) of each device must be used when available, and when the destruction device is not listed in table A.6. If a site-specific methane destruction efficiency for devices listed in table A.6 is not available then the default value from table A.6 must be used. Site-specific methane destruction efficiencies require prior written approval from the Executive Officer and must be equally or more accurate than the default destruction efficiencies.

(e) Biogas flow to an inoperable device must be counted as a separate device with a biogas destruction efficiency (BDE_j) of zero when calculating the fractional monthly weighted average destruction efficiency of devices used during the month ($BDE_{i,weighted}$).

Equation 5.10 : Metered Methane Destruction

$$CH_{4,destroyed} = \sum_i (CH_{4meter,i} \times BDE_{i,weighted}) \times GWP_{CH4}$$

Where,			Units
$CH_{4,destroyed}$	=	Aggregated quantity of methane collected and destroyed during the reporting period	$mtCO_2e$
$CH_{4\ meter,i}$	=	Monthly quantity of methane collected and metered.	$mtCH_4$/ month
$BDE_{i,weighted}$	=	Monthly weighted average of all destruction devices used in month *i*	fraction (0-1)
GWP_{CH4}	=	Global warming potential of methane	

With:

$$CH_{4\ meter,i} = F_i \times C_{CH4} \times 0.0423 \times 0.000454$$

Where,			Units
C_{CH4}	=	Quarterly methane concentration	fraction (0-1)
F_i	=	Volume of biogas from the digester in month *i*	scf

And:

$$BDE_{i,weighted} = \frac{\sum_j (F_{j,i} \times BDE_j)}{\sum_j F_{F\,j,i}}$$

Where:			Units
j	=	Destruction devices	
$F_{j,i}$	=	Volume of biogas in month *i* sent to destruction device *j*	scf
BDE_j	=	Biogas destruction efficiency of device *j*	Fraction (0-1)

(f) If gas flow metering equipment does not internally correct gas flow volumes to standard conditions, the Offset Project Operator or, if applicable, the Authorized Project Designee must apply equation 5.11 to the volume of biogas prior to calculating metered methane destruction in eqution 5.10.

Equation 5.11: Biogas Volume corrected for Temperature and Pressure

$$F_{corrected,y} = F_{meas,y} \times \frac{519.67}{T_{meas,y}} \times \frac{P_{meas,y}}{1.00}$$

Where: Units

$F_{corrected,y}$	=	Corrected volume of biogas for time interval y, adjusted to 60 ^{o}F and 1 atm	scf
$F_{meas,y}$	=	Measured volume of biogas for time interval y	cf
$T_{meas,y}$	=	Measured temperature of the biogas for time interval y, $^{o}R = {}^{o}F + 459.67$	^{o}R
Pmeas,y	=	Measured pressure of the biogas for the time interval y	atm

5.4. Quantifying Project Baseline and Project Carbon Dioxide Emissions

(a) Carbon dioxide emissions associated with the project baseline or project activities include, but are not limited to, the following sources:

(1) Electricity use by pumps and equipment;

(2) Fossil fuel generators used to destroy biogas;

(3) Power pumping systems;

(4) Milking parlor equipment;

(5) Flares;

(6) Tractors that operate in barns or freestalls;

(7) On-site manure hauling trucks; and

(8) Vehicles that transport manure off-site.

(b) If it is demonstrated during verification that project carbon dioxide emissions are to be equal to or less than 5% of the total project baseline emissions of methane, project baseline and project carbon dioxide emissions may be estimated.

(c) Baseline carbon dioxide emissions (BE_{CO2}) must be calculated using equation 5.12.

(d) The baseline quantities of electricity ($BE_{QE,c}$) and fossil fuel ($BE_{QF,c}$) consumed by each source must be taken from operational records such as utility bills and delivery invoices unless the Offset Project Operator or Authorized Project Designee is allowed to estimate baseline carbon dioxide emissions pursuant to subchapter 5.4(b) of this protocol.

(e) If the total electricity being generated by project activities is greater than or equal to the additional electricity consumption by the project ($PE_{QE,c}$ - $BE_{QE,c}$) the baseline ($BE_{QE,c}$) and project ($PE_{QE,c}$) electricity consumption will both be set to zero.

Equation 5.12 Baseline Carbon Dioxide Emissions

$$BE_{CO2} = \sum_{c}(BE_{QE,c} \times EF_{CO2,e}) + \sum_{c}(BE_{QF,c} \times EF_{CO2,f}) \times 0.001$$

Where,			Units
BE_{CO2}	=	Baseline anthropogenic carbon dioxide emissions from electricity consumption and mobile and stationary combustion sources	mtCO2e
$BE_{QE,c}$	=	Baseline quantity of electricity consumed for each emissions source 'c'	MWh
$EF_{CO2,e}$	=	CO_2 emission factor *e* for electricity used; see appendix A for emission factors by eGRID subregion	mtCO2/MWh
$EF_{CO2,f}$	=	Fuel-specific emission factor *f* from appendix A	kg CO2/MMBtu or kg CO2/gal
$BE_{QF,c}$	=	Baseline quantity of fuel consumed for each mobile and stationary emission source 'c'	MMBtu or gal
0.001	=	Conversion factor from kg to mt	

(f) Project carbon dioxide emissions (PE_{CO2}) must be calculated using equation 5.13.

(g) The project quantities of electricity ($PE_{QE,c}$) and fossil fuel ($PE_{QF,c}$) consumed by each source must be taken from operational records such as utility bills and delivery invoices unless the Offset Project Operator or Authorized Project Designee is allowed to estimate project carbon dioxide emissions pursuant to subchapter 5.4(b) of this protocol.

Equation 5.13 Project Carbon Dioxide Emissions

$$PE_{CO2} = \sum_{c}(PE_{QE,c} \times EF_{CO2,e}) + \sum_{c}(PE_{QF,c} \times EF_{CO2,f}) \times 0.001$$

Where,			Units
PE_{CO2}	=	Project anthropogenic carbon dioxide emissions from electricity consumption and mobile and stationary combustion sources	mtCO2e
$PE_{QE,c}$	=	Project quantity of electricity consumed for each emissions source 'c'	MWh

$EF_{CO2,e}$	=	CO_2 emission factor *e* for electricity used; see appendix A for emission factors by eGRID sub region	mtCO2/MWh
$EF_{CO2,f}$	=	Fuel-specific emission factor *f* from appendix A	kg CO2/MMBtu or kg CO2/gal
$PE_{QF,c}$	=	Project quantity of fuel consumed for each mobile and stationary emission source ‘c’	MMBtu or gal
0.001	=	Conversion factor from kg to mt	

Chapter 6. Monitoring

6.1. General Monitoring Requirement - Quantification Methodology

(a) The Offset Project Operator or Authorized Project Designee is responsible for monitoring the performance of the offset project and operating each component of the biogas collection and destruction system in a manner consistent with the manufacturer’s specifications.

(b) The Offset Project Operator or, if applicable, the Authorized Project Designee must monitor the methane capture and control system with measurement equipment that directly meters:

  (1) The total flow of biogas, measured continuously and recorded every 15 minutes or totalized and recorded at least daily, adjusted for temperature and pressure, prior to delivery to the destruction device(s);

  (2) The total flow of biogas can come from one meter or summed from multiple meters;

  (3) The flow of biogas delivered to each destruction device, measured continuously and recorded every 15 minutes or totalized and recorded at least daily, adjusted for temperature and pressure. A single meter may be used for multiple destruction devices. In this instance, methane destruction in these devices is eligible only if the operational activity of all these devices are independently monitored and the least efficient BDE of all destruction devices is used; and

  (4) The fraction of methane in the biogas must be measured with a continuous analyzer or, alternatively, with quarterly measurements.

(c) Flow data must be corrected for temperature and pressure at 60^oF and 1 atm, either internally or by following equation 5.6.

(d) The Offset Project Operator or, if applicable, the Authorized Project Designee must independently monitor the operational activity of each destruction device and must collect and maintain documentation at least hourly to ensure actual methane destruction. No registry offset credits or ARB offset credits will be issued for any time period during which the destruction device is not operational.

(1) Any destruction device equipped with a safety shut off device that prevents biogas flow to the destruction device when the destruction device is not operational does not require hourly monitoring, provided that the presence, operability, and use of the safety device are verified.

(e) If for any reason the destruction device or the operational monitoring equipment is inoperable, during the period of inoperability, the destruction efficiency of the device is zero.

(f) Data substitution is allowed for limited circumstances where a project encounters biogas flow rate or methane concentration data gaps. The Offset Project Operator or, if applicable, Authorized Project Designee must apply the data substitution methodology provided in appendix B. No data substitution is permissible for data gaps resulting from inoperable equipment that monitors the proper functioning of destruction devices, and no emission reductions will be credited under such circumstances.

(g) Data substitution is required for all circumstances where a projects encounters project flow rate or methane concentration gaps. The Offset Project Operator or, if applicable, Authorized Project Designee must apply the data substitution methodology provided in appendix B. No data substitution is permissible for data gaps resulting from inoperable equipment that monitors the proper functioning of destruction devices and no emission reductions will be credited under such circumstances.

6.2. Biogas Measurement Instrument QA/QC – Quantification Methodology

(a) All gas flow meters and continuous methane analyzers must be:

(1) Cleaned and inspected on a quarterly basis, with the activities performed and “as found/as left condition” of the equipment documented;

(2) Field checked by a trained professional for calibration accuracy with the percent drift documented, using either a portable instrument (such as a pitot tube), a permanent fixture or manufacturer specifications, at the end of but no more than two months prior to the end date of the reporting period; and

(3) Calibrated by the manufacturer or a certified calibration service per manufacturer's specifications or every 5 years, whichever is more frequent.

(b) If the field check on a piece of equipment after cleaning reveals accuracy outside of a +/- 5% threshold, the equipment must be calibrated by the manufacturer or a certified service provider. The Offset Project Operator or, if applicable, Authorized Project Designee must maintain documentation of efforts to calibrate the equipment within 30 days of the failed field check or a biogas destruction efficiency of zero must be assigned to all destruction devices monitored by the equipment from date of discovery until calibration.

(c) For the interval between the last successful field check and any calibration event confirming accuracy outside the +/- 5% threshold, all data from that meter or analyzer must be scaled according to the following procedure. These adjustments must be made for the entire period from the last successful field check until such time as the meter is properly calibrated.

(1) For calibrations that indicate the flow meter was outside the +/- 5% accuracy threshold, the project developer must estimate total emission reductions independently for each meter using:

(A) The metered values without correction; and

(B) The metered values adjusted based on the greatest calibration drift recorded at the time of calibration.

(2) The lower of the two emission reduction estimates must be reported as the scaled emission reduction estimate.

(d) If a portable instrument is used (such as a handheld methane analyzer), the portable instrument must be calibrated per manufacturer's specifications or at least once during each reporting period, whichever is more frequent, by the manufacturer or at an ISO 17025 certified laboratory.

6.3. Document Retention

(a) The Offset Project Operator or Authorized Project Designee is required to keep all documentation and information outlined in the Regulation and this protocol. Record retention requirements are set forth in section 95976 of the Regulation.

(b) Information that must be retained by the Offset Project Operator or Authorized Project Designee must include, but is not limited to:

(1) All data inputs for the calculation of the project baseline emissions and project emission reductions;

(2) Emission reduction calculations;

(3) Relevant sections of the BCS operating permits;

(4) BCS information (installation dates, equipment list, etc.);

(5) Biogas flow meter information (model number, serial number, manufacturer's calibration procedures) ;

(6) Cleaning and inspection records for all biogas meters;

(7) Field check results for all biogas meters;

(8) Calibration results for all biogas meters;

(9) Methane monitor information (model number, serial number, calibration procedures);

(10) Biogas flow data (for each flow meter);

(11) Biogas temperature and pressure readings (only if flow meter does not correct for temperature and pressure automatically);

(12) Methane concentration monitoring data;

(13) Destruction device monitoring data (for each destruction device);

(14) Destruction device, methane monitor and biogas flow monitor information (model numbers, serial numbers, calibration procedures); and

(15) All maintenance records relevant to the BCS, monitoring equipment, and destruction devices.

(c) If using a calibrated portable gas analyzer for CH_4 content measurement, all of the following information must also be included:

(1) Date, time, and location of methane measurement;

(2) Methane content of biogas (% by volume) for each measurement ;

(3) Methane measurement instrument type and serial number;

(4) Date, time, and results of instrument calibration; and

(5) Corrective measures taken if instrument does not meet performance specifications.

(d) See the Regulation for additional record-keeping requirements.

6.4. Monitoring Parameters – Quantification Methodology

Provisions for monitoring other variables to calculate project baseline and project emissions are provided in table 6.1.

Table 6.1. Project Monitoring Parameters

Eq. #	Parameter	Description	Data unit	calculated (c) measured (m) reference(r) operating records (o)	Measurement frequency	Comment
General Project Parameters						
5.1 5.6 5.10	$CH_{4\ meter}$	Amount of methane collected and metered in BCS	Metric tons of CH4 (tCH4)	c, m	Monthly	Calculated from biogas flow and methane fraction meter readings (See 'F' and 'C_{CH4}' parameters below). Verifier: Review meter reading data; Confirm proper operation and maintenance in accordance with the manufacturer's specifications; Confirm meter calibration data.
5.2 5.3	L	Type of livestock categories on the farm	Livestock categories	o	Monthly	Select from list provided in table A.1. Verifier: Review herd management software; Conduct site visit; Interview operator.
5.3	VS_{deg}	Monthly volatile solids degraded in each anaerobic storage system, for each livestock category	kg	c, o	Monthly	Calculated value from operating records. *Verifier*: Ensure proper calculations; Review operating records.
5.3 5.4 5.8 5.9	$B_{0,L}$	Maximum methane producing capacity for manure by livestock category	(m3 CH4/kgVS)	r	Once per reporting period	From table A.2. Verifier: Verify correct value from table used.
5.3	VS_{avail}	Monthly volatile solids available for degradation in each anaerobic storage system, for each livestock category	kg	c, o	Monthly	Calculated value from operating records. Verifier: Ensure proper calculations; Review operating records.
5.3 5.4 5.8 5.9	VS_L	Daily volatile solid production	(kg/animal/ day)	r, c	Once per reporting period	From table A.2 and table A.4; Verifier: Ensure appropriate year's table is used; Review data units.

5.3	f	Van't Hoff-Arrhenius factor	n/a	c	Monthly	The proportion of volatile solids that are biologically available for conversion to methane based on the monthly temperature of the system. Verifier: Ensure proper calculations; Review calculation; Review temperature data.
5.3 5.4 5.8 5.9	P_L	Average number of animals for each livestock category	Population (# head)	o	Monthly	Verifier: Review herd management software; Review local air and water quality agency reporting submissions, if available (e.g. in CA, dairies with more than 500 cows report farm information to ARB).
5.3 5.4 5.8 5.9	$Mass_L$	Average live weight by livestock category	kg	o, r	Monthly	From operating records, or if on-site data is unavailable, from lookup table (table A.1). Verifier: Conduct site visit; Interview livestock operator; Review average daily gain records, operating records.
5.3	T_2	Average monthly temperature at location of the operation	oC	m/o	Monthly	Used for van't Hoff-Arrhenius factor calculation and for choosing appropriate MCF value. Verifier: Review temperature records obtained from weather service.
5.6	$CH_{4\ meter,i}$	Quantity of methane collected and metered in month i	$mtCH_4$/Month	m/o	Monthly	Used for calculating $PE_{CH4,\ BCS}$.
5.6	BCE	Biogas capture efficiency of the anaerobic digester, accounts for gas leaks.	Fraction (0-1)	r	Once per reporting period	Use default value from table A.3. Verifier: Review operation and maintenance records to ensure proper functionality of BCS.

5.6 5.10	BDE	Methane destruction efficiency of destruction device(s)	Fraction (0-1)	r, c	Monthly	Reflects the actual efficiency of the system to destroy captured methane gas – accounts for different destruction devices. See Equation 5.6. Verifier: Confirm evidence of proper and continuous operation in accordance with the manufacturer's specifications.
5.6	C_{CH4}	Methane concentration of biogas	Fraction (0-1)	m	Quarterly	Use a direct sampling approach that yields a value with at least 95% confidence. Samples to be taken at least quarterly. Calibrate monitoring instrument in accordance with the manufacturer's specifications. Verifier: Review meter reading data; Confirm proper operation in accordance with the manufacturer's specifications.
5.6 5.7 5.10 5.11	F	Monthly volume of biogas from digester to destruction devices	scf/month	m	Continuously, aggregated monthly	Measured continuously from flow meter and recorded every 15 minutes or totalized and recorded at least once daily. Data to be aggregated monthly. Verifier: Review meter reading data; Confirm proper aggregation of data; Confirm proper operation in accordance with the manufacturer's specifications; Confirm meter calibration data.
5.6	F_{pw}	The average flow of biogas from the digester for the entire week prior to the uncontrolled venting event	scf/day	m	Weekly	The average flow of biogas can be determined from the daily records from the previous week.
5.6	t	The number of days of the month that biogas is venting uncontrolled from the project's BCS.	Days	m, o	Monthly	

5.6	MS_{BCS}	The maximum biogas storage of the BCS system	scf	r	Once per reporting period	Obtained from digester system design plans. Necessary to quantify the release of methane to the atmosphere due to an uncontrolled venting event.
5.7 5.11	T	Temperature of the biogas	°R (Rankine)	m	Continuously, averaged monthly	Measured to normalize volume flow of biogas to STP. No separate monitoring of temperature is necessary when using flow meters that automatically measure temperature and pressure, expressing biogas volumes in normalized cubic feet.
5.8	VS_{ep}	Average daily volatile solid of digester effluent to effluent pond	kg/day	c	Once per reporting period	If project uses effluent pond, equals 30% of the average daily VS entering the digester. Verifier: Review VSep calculations.
5.8	MCF_{ep}	Methane conversion factor for BCS effluent pond	Fraction (0-1)	r	Once per reporting period	Referenced from appendix A. The Offset Project Operator or Authorized Project Designee must use the liquid slurry MCF value. Verifier: Verify value from table.
5.8	$MS_{L,BCS}$	Fraction of manure from each livestock category managed in the BCS	Fraction (0-1)	o	Once per reporting period	Used to determine the total VS entering the digester. The percentage should be tracked in operational records. Verifier: Check operational records and conduct site visit.
5.9	$EF_{CH4,L}$ (nBCSs)	Methane emission factor for the livestock population from non-BCS-related sources	(kgCH4/head/year)	c	Once per reporting period	Emission factor for all non-BCS storage systems, differentiated by livestock category. Verifier: Review calculation, operation records.
5.9	MCF_s	Methane conversion factor for manure management system component 'S'	Fraction (0-1)	r	Once per reporting period	From appendix A. Differentiate by livestock category Verifier: Verify correct value from table used.

5.9	MS_L	Fraction of manure from each livestock category managed in the baseline waste handling system 'S'	Fraction (0-1)	o	Once per reporting period	Reflects the percent of waste handled by the system components 'S' pre-project. Applicable to the entire operation. Within each livestock category, the sum of MS values (for all treatment/storage systems) equals 100%. Verifier: Conduct site visit; Interview operator; Review baseline scenario documentation.
5.9	$MS_{L,S}$	Fraction of manure from each livestock category managed in non-anaerobic manure management system component 'S'	Fraction (0-1)	o	Monthly	Based on configuration of manure management system, differentiated by livestock category. Verifier: Conduct site visit; Interview operator.
5.10	$CH_{4,destroyed}$	Aggregated amount of methane collected and destroyed in the BCS	Metric tons of CH4	c, m	Once per reporting period	Calculated as the collected methane times the destruction efficiency (see the 'CH4,meter ' and 'BDE' parameters below) Verifier: Review meter reading data, confirm proper operation of the destruction device(s); Ensure data is accurately aggregated over the correct amount of time.
5.12	BE_{QEc}	Baseline quantity of electricity consumed	MWh/year	o, c	Once per reporting period	Electricity used by project for manure collection, transport, treatment/storage, and disposal. Verifier: Review operating records and quantity calculation.
5.12 5.13	$EF_{CO2,e}$	Emission factor for electricity used by project	tCO2/MWh	r	Once per reporting period	Refer to appendix A for emission factors. If biogas produced from digester is used to generate electricity consumed, the emission factor is zero. Verifier: Review emission factors.

5.12 5.13	$EF_{CO2,f}$	Fuel-specific emission factor for mobile and stationary combustion sources	kg CO2/MMBTU or kg CO2/gallon	r	Once per reporting period	Refer to appendix A for emission factors. If biogas produced from digester is used as an energy source, the emission factor is zero. Verifier: Review emission factors.
5.12	BE_{QFc}	Baseline quantity of fuel used for mobile/stationary combustion sources	MMBTU/year or gallon/year	o, c	Once per reporting period	Fuel used by project for manure collection, transport, treatment/storage, and disposal, and stationary combustion sources including supplemental fossil fuels used in combustion device. Verifier: Review operating records and quantity calculation.
5.13	PE_{QEc}	Project quantity of electricity consumed	MWh/year	o, c	Once per reporting period	Electricity used by project for manure collection, transport, treatment/storage, and disposal. Verifier: Review operating records and quantity calculation.
5.13	PE_{QFc}	Project quantity of fuel used for mobile/stationary combustion sources	MMBTU/year or gallon/year	o, c	Once per reporting period	Fuel used by project for manure collection, transport, treatment/storage, and disposal, and stationary combustion sources including supplemental fossil fuels used in combustion device. Verifier: Review operating records and quantity calculation.

Chapter 7. Reporting

General requirements for reporting and record retention are included in the Regulation. In addition to the offset project requirements in sections 95975 and 95976 the Regulation, livestock offset projects must follow the project listing and reporting requirements below.

7.1. Listing Requirements

(a) Listing information must be submitted by the Offset Project Operator or Authorized Project Designee no later than the date on which the Offset Project Operator or Authorized Project Designee submits the first Offset Project Data Report.

(b) In order for a livestock Compliance Offset Project to be listed, the Offset Project Operator or Authorized Project Designee must submit the information required by section 95975 of the Regulation, in addition to all the following information:

- (1) Offset project name and ID number(s);
- (2) Name and CITSS ID number for the:
  - (A) Offset Project Operator; and,
  - (B) Authorized Project Designee (if applicable);
- (3) Contact information for both the Offset Project Operator and, if applicable, the Authorized Project Designee, including all of the following information:
  - (A) Entity's mailing address;
  - (B) Contact person's name;
  - (C) Contact person's phone number; and
  - (D) Contact person's email address;
- (4) Contact information, including name, phone number, email address, and, if applicable, the organizational affiliation for:
  - (E) The person submitting the listing information;
  - (F) Technical consultants; and
  - (G) Other parties with a material interest;
- (5) Name of facility owner;
- (6) Date of form completion;
- (7) Offset project description: 1-2 paragraphs (including type of digester and method of destruction);
- (8) Offset project site address (including all governing jurisdictions and latitude/longitude);

(9) Name and address of animal facility (if different from project site);

(10) Description of type of facility (e.g., dairy, swine, or combined);

(11) Offset project commencement date;

(12) Initial reporting period start and end dates;

(13) Indication whether any GHG reductions associated with the offset project have ever been registered with or claimed by another registry or program, or sold to a third party prior to our listing; if so, identification of the registry or program, as well as vintage and reporting period; and

(14) Indication whether the offset project is being implemented and conducted as the result of any law, statute, regulation, court order, or other legally binding mandate. If so, an explanation must also be provided;

7.2. Offset Project Data Report

(a) The Offset Project Operator or, if applicable, Authorized Project Designee must submit an Offset Project Data Report at the conclusion of each Reporting Period according to the reporting schedule in section 95976 of the Regulation.

(b) The Offset Project Operator or, if applicable, Authorized Project Designee must submit the information required by section 95976 of the Regulation, in addition to all of the following information:

(1) Offset project name and ID number(s);

(2) Name and CITSS ID number for the:

(A) Offset Project Operator; and,

(B) Authorized Project Designee (if applicable);

(3)

(C) Contact information for both the Offset Project Operator and, if applicable, the Authorized Project Designee, including all of the following information: Entity’s mailing address;

(D) Contact person’s name;

(E) Contact person’s phone number; and

(F) Contact person’s email address;

(4) Contact information including name, phone number, email address, and, if applicable, the organization affiliation for the person submitting the reporting information;

(5) Date OPDR completed;

(6) Reporting period start and end dates;

(7) Indication whether the offset project meets all local, state, or federal regulatory requirements;

(8) Offset project commencement date;

(9) Facility name and location;

(10) Indication whether all the information in the offset project listing is still accurate. If not provide updates;

(11) Project baseline emissions;

(12) Project emissions; and

(13) Total GHG emission reductions.

Chapter 8. Verification

(a) All Offset Project Data Reports are subject to regulatory verification as required in section 95977 of the Regulation by an ARB accredited offset verification body.

(b) The Offset Project Data Reports must receive a positive or qualified positive verification statement to be issued ARB or registry offset credits.

Appendix A Emissions Factor Tables – Quantification Methodology

Table A.1. Livestock Categories and Typical Average Mass ($Mass_L$)

Livestock Category (L)	Livestock Typical Average Mass (TAM) in kg
Dairy cows (on feed)	680
Non-milking dairy cows (on feed)	684
Heifers (on feed)	407
Bulls (grazing)	874
Calves (grazing)	118
Heifers (grazing)	351.5
Cows (grazing)	582.5
Nursery swine	12.5
Grow/finish swine	70
Breeding swine	198

Table A.2. Volatile Solids and Maximum Methane Potential by Livestock Category

Livestock category (*L*)	VS_{Table} (kg/day/1,000 kg mass)	$B_{o,L}$ (m^3 CH_4/kg VS added)
Dairy cows	See table A.4	0.24
Non-milking dairy cows	5.56	0.24
Heifers	See table A.4	0.17
Bulls (grazing)	6.04	0.17
Calves (grazing)	7.70	0.17
Heifers (grazing)	See table A.4	0.17
Cows (grazing)	See table A.4	0.17
Nursery swine	8.89	0.48
Grow/finish swine	5.36	0.48
Breeding swine	2.71	0.35

Table A.3. Biogas Collection Efficiency by Digester Type

Digester Type	Cover Type	Biogas Collection Efficiency (BCE)
Covered Anaerobic Lagoon	Bank-to-Bank, impermeable	0.95
	Partial area (modular), impermeable	0.95 x % area covered
Complete mix, plug flow, or fixed film digester	Enclosed vessel	0.98

Table A.4. 2012 Volatile Solid (VS_{table}). Default Values for Dairy Cows, Heifers, Heifers-Grazing and Cows- Grazing by State (kg/day/1000 kg mass)

State	VS Dairy Cow	VS Heifer	VS Heifer-Grazing	VS Cows- Grazing
Alabama	8.62	8.44	19.67	7.82
Alaska	8.71	8.44	30.94	8.89
Arizona	11.64	8.44	22.32	8.89
Arkansas	8.44	8.44	18.38	7.82
California	11.41	8.44	13.96	8.89
Colorado	11.64	8.44	12.28	8.89
Connecticut	10.41	8.44	23.35	7.87
Delaware	10.18	8.44	16.82	7.87
Florida	10.36	8.44	21.99	7.82
Georgia	10.40	8.44	19.17	7.82
Hawaii	8.70	8.44	20.25	8.89
Idaho	11.45	8.44	13.75	8.89
Illinois	10.30	8.44	11.42	7.47
Indiana	10.85	8.44	11.72	7.47
Iowa	10.96	8.44	9.54	7.47
Kansas	10.94	8.44	8.99	7.47
Kentucky	9.20	8.44	14.69	7.82
Louisiana	8.41	8.44	21.36	7.82
Maine	10.01	8.44	15.12	7.87
Maryland	10.20	8.44	17.18	7.87
Massachusetts	9.91	8.44	20.89	7.87
Michigan	11.56	8.44	12.19	7.47
Minnesota	10.29	8.44	11.47	7.47
Mississippi	8.96	8.44	19.31	7.82
Missouri	8.92	8.44	14.84	7.47
Montana	10.85	8.44	18.50	7.82
Nebraska	10.79	8.44	11.97	8.89
Nevada	11.33	8.44	14.77	7.47
New Hampshire	10.34	8.44	23.83	8.92
New Jersey	10.01	8.44	16.56	7.87
New Mexico	11.85	8.44	14.27	7.87
New York	10.93	8.44	16.72	8.89
North Carolina	10.79	8.44	19.93	7.87
North Dakota	10.22	8.44	14.61	7.82
Ohio	10.39	8.44	13.24	7.47
Oklahoma	9.76	8.44	12.67	7.47
Oregon	10.57	8.44	15.75	7.82

Pennsylvania	10.32	8.44	16.19	8.89
Rhode Island	9.93	8.44	20.89	7.87
South Carolina	9.85	8.44	19.71	7.87
South Dakota	10.86	8.44	12.77	7.82
Tennessee	9.49	8.44	16.25	7.47
Texas	11.06	8.44	11.15	7.82
Utah	10.95	8.44	16.65	7.82
Vermont	10.23	8.44	16.08	8.89
Virginia	10.06	8.44	17.93	7.87
Washington	11.58	8.44	12.06	7.82
West Virginia	9.18	8.44	19.13	8.89
Wisconsin	10.87	8.44	17.03	7.47
Wyoming	10.69	8.44	18.18	8.89

Table A.5. IPCC 2006 Methane Conversion Factors by Manure Management System Component/Methane Source 'S'

MCF VALUES BY TEMPERATURE FOR MANURE MANAGEMENT SYSTEMS																					
System		MCFs by average reporting period temperature (°C)																			Source and comments
		Cool					Temperate											Warm			
		≤ 10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	≥ 28	
Pasture/Range/Paddock		0.01					0.02											0.02			Judgment of IPCC Expert Group in combination with Hashimoto and Steed (1994).
Daily spread		0.001					0.02											0.01			Hashimoto and Steed (1993).
Solid storage		0.02					0.04											0.05			Judgment of IPCC Expert Group in combination with Amon et al. (2001), which shows emissions of approximately 2% in winter and 4% in summer. Warm climate is based on judgment of IPCC Expert Group and Amon et al. (1998).
Dry lot		0.01					0.02											0.02			Judgment of IPCC Expert Group in combination with Hashimoto and Steed (1994).
Liquid / Slurry	With natural crust cover	0.10	0.11	0.13	0.14	0.15	0.17	0.18	0.20	0.22	0.24	0.26	0.29	0.31	0.34	0.37	0.41	0.44	0.48	0.50	Judgment of IPCC Expert Group in combination with Mangino et al. (2001) and Sommer (2000). The estimated reduction due to the crust cover (40%) is an annual average value based on a limited data set and can be highly variable

																					dependent on temperature, rainfall, and composition. When slurry tanks are used as fed-batch storage/digesters , MCF should be calculated according to Formula 1.
	W/out natural crust cover	0.17	0.19	0.20	0.22	0.25	0.27	0.29	0.32	0.35	0.39	0.42	0.46	0.50	0.55	0.60	0.65	0.71	0.78	0.80	Judgment of IPCC Expert Group in combination with Mangino et al. (2001). When slurry tanks are used as fed-batch storage/digesters , MCF should be calculated according to Formula 1.

Table A.5. Continued

MCF VALUES BY TEMPERATURE FOR MANURE MANAGEMENT SYSTEMS																					
System		MCFs by average reporting period temperature (°C)																			Source and comments
		Cool					Temperate											Warm			
		≤ 10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	≥ 28	
Uncovered anaerobic lagoon		0.66	0.68	0.70	0.71	0.73	0.74	0.75	0.76	0.77	0.77	0.78	0.78	0.78	0.79	0.79	0.79	0.79	0.80	0.80	Judgment of IPCC Expert Group in combination with Mangino et al. (2001). Uncovered lagoon MCFs vary based on several factors, including temperature, retention time, and loss of volatile solids from the system (through removal of lagoon effluent and/or solids).
Pit storage below animal confinements	< 1 month	0.03					0.03											0.03			Judgment of IPCC Expert Group in combination with Moller et al. (2004) and Zeeman (1994). Note that the ambient temperature, not the stable temperature is to be used for determining the climatic conditions. When pits used as fed-batch storage/digesters, MCF should be calculated according to Formula 1.
	> 1 month	0.19	0.19	0.20	0.22	0.25	0.27	0.29	0.32	0.35	0.39	0.42	0.46	0.50	0.55	0.60	0.65	0.71	0.78	0.80	Judgment of IPCC Expert Group in combination with Mangino et al. (2001). Note that the ambient temperature, not the stable temperature is to be used for determining the climatic conditions. When pits used as fed-batch storage/digesters, MCF should be calculated according to Formula 1.

Table A.5. Continued

MCF VALUES BY TEMPERATURE FOR MANURE MANAGEMENT SYSTEMS																				
System		MCFs by average reporting period temperature (°C)																		Source and comments
		Cool					Temperate											Warm		
		≤ 10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	≥ 28	
Anaerobic digester		0.0-1.00					0.0-1.00											0.0-1.00			Should be subdivided in different categories, considering amount of recovery of the biogas, flaring of the biogas and storage after digestion. Calculation with Formula 1.
Burned for fuel		0.10					0.10											0.10			Judgment of IPCC Expert Group in combination with Safley et al. (1992).
Cattle and Swine deep bedding	< 1 month	0.03					0.03											0.30			Judgment of IPCC Expert Group in combination with Moller et al. (2004). Expect emissions to be similar, and possibly greater, than pit storage, depending on organic content and moisture content.
Cattle and Swine deep bedding (cont.)	> 1 month	0.17	0.19	0.20	0.22	0.25	0.27	0.29	0.32	0.35	0.39	0.42	0.46	0.50	0.55	0.60	0.65	0.71	0.78	0.90	Judgment of IPCC Expert Group in combination with Mangino et al. (2001).
Composting - In-vessel[a]		0.005					0.005											0.005			Judgment of IPCC Expert Group and Amon et al. (1998). MCFs are less than half of solid storage. Not temperature dependant.
Composting - Static pile[a]		0.005					0.005											0.005			Judgment of IPCC Expert Group and Amon et al. (1998). MCFs are less than half of solid storage. Not temperature dependant.

Table A.5. Continued

Composting - Intensive windrow[a]	0.005	0.01	0.015	Judgment of IPCC Expert Group and Amon et al. (1998). MCFs are slightly less than solid storage. Less temperature dependant.
Composting – Passive windrow[a]	0.005	0.01	0.015	Judgment of IPCC Expert Group and Amon et al. (1998). MCFs are slightly less than solid storage. Less temperature dependant.
Aerobic treatment	0.00	0.00	0.00	MCFs are near zero. Aerobic treatment can result in the accumulation of sludge which may be treated in other systems. Sludge requires removal and has large VS values. It is important to identify the next management process for the sludge and estimate the emissions from that management process if significant.
a Composting is the biological oxidation of a solid waste including manure usually with bedding or another organic carbon source typically at thermophilic temperatures produced by microbial heat production.				

Table A.6. Biogas Destruction Efficiency Default Values by Destruction Device

If available, the actual source test results for the measured methane destruction efficiency must be used in place of the default methane destruction efficiency. Otherwise, the Offset Project Operator or Authorized Project Designee must use the default methane destruction efficiencies provided below.

Biogas Destruction Device	Biogas Destruction Efficiency (BDE)
Open Flare	0.96
Enclosed Flare	0.995
Lean-burn Internal Combustion Engine	0.936
Rich-burn Internal Combustion Engine	0.995
Boiler	0.98
Microturbine or large gas turbine	0.995
Upgrade and use of gas as CNG/LNG fuel	0.95
Upgrade and injection into natural gas transmission and distribution pipeline	0.98
Direct pipeline to an end-user	Per corresponding destruction device

Table A.7. CO2 Emission Factors for Fossil Fuel Use

Fuel Type	Default High Heat Value	Default CO_2 Emission Factor	Default CO_2 Emission Factor
Coal and Coke	**MMBtu / short ton**	**kg CO_2 / MMBtu**	**kg CO_2 / short ton**
Anthracite	25.09	103.54	2597.819
Bituminous	24.93	93.40	2328.462
Subbituminous	17.25	97.02	1673.595
Lignite	14.21	96.36	1369.276
Coke	24.80	102.04	2530.592
Mixed (Commercial sector)	21.39	95.26	2037.611
Mixed (Industrial coking)	26.28	93.65	2461.122
Mixed (Electric Power sector)	19.73	94.38	1862.117
Natural Gas	**MMBtu / scf**	**kg CO_2 / MMBtu**	**kg CO_2 / scf**
(Weighted U.S. Average)	1.028×10^{-3}	53.02	0.055
Petroleum Products	**MMBtu / gallon**	**kg CO_2 / MMBtu**	**kg CO_2 / gallon**
Distillate Fuel Oil No. 1	0.139	73.25	10.182
Distillate Fuel Oil No. 2	0.138	73.96	10.206
Distillate Fuel Oil No. 4	0.146	75.04	10.956
Distillate Fuel Oil No. 5	0.140	72.93	10.210
Residual Fuel Oil No. 6	0.150	75.10	11.265
Used Oil	0.135	74.00	9.990
Kerosene	0.135	75.20	10.152
Liquefied petroleum gases (LPG)	0.092	62.98	5.794
Propane	0.091	61.46	5.593
Propylene	0.091	65.95	6.001
Ethane	0.069	62.64	4.322
Ethanol	0.084	68.44	5.749
Ethylene	0.100	67.43	6.743
Isobutane	0.097	64.91	6.296
Isobutylene	0.103	67.74	6.977
Butane	0.101	65.15	6.580
Butylene	0.103	67.73	6.976
Naphtha (<401 deg F)	0.125	68.02	8.503
Natural Gasoline	0.110	66.83	7.351
Other Oil (>401 deg F)	0.139	76.22	10.595
Pentanes Plus	0.110	70.02	7.702
Petrochemical Feedstocks	0.129	70.97	9.155
Petroleum Coke	0.143	102.41	14.645
Special Naphtha	0.125	72.34	9.043
Unfinished Oils	0.139	74.49	10.354
Heavy Gas Oils	0.148	74.92	11.088

Lubricants	0.144	74.27	10.695
Motor Gasoline	0.125	70.22	8.778
Aviation Gasoline	0.120	69.25	8.310
Kerosene-Type Jet Fuel	0.135	72.22	9.750
Asphalt and Road Oil	0.158	75.36	11.907
Crude Oil	0.138	74.49	10.280
Other fuels (solid)	**MMBtu / short ton**	**kg CO_2 / MMBtu**	**kg CO_2 / short ton**
Municipal Solid Waste	9.95	90.7	902.465
Tires	26.87	85.97	2310.014
Plastics	38.00	75.00	2850.000
Petroleum Coke	30.00	102.41	3072.300
Other fuels (gaseous)	**MMBtu / scf**	**kg CO_2 / MMBtu**	**kg CO_2 / scf**
Blast Furnace Gas	0.092×10^{-3}	274.32	0.025
Coke Oven Gas	0.599×10^{-3}	46.85	0.028
Propane Gas	2.516×10^{-3}	61.46	0.155
Fuel Gas	1.388×10^{-3}	59.00	0.082
Biomass Fuels (solid)	**MMBtu / short ton**	**kg CO2 / MMBtu**	**kg CO_2 / short ton**
Wood and Wood Residuals	15.38	93.80	1442.644
Agricultural Byproducts	8.25	118.17	974.903
Peat	8.00	111.84	894.720
Solid Byproducts	25.83	105.51	2725.323
Biomass Fuels (gaseous)	**MMBtu / scf**	**kg CO2 / MMBtu**	**kg CO_2 / scf**
Biogas (Captured methane)	0.841 x 10-3	52.07	0.044
Biomass Fuels (liquid)	**MMBtu / gallon**	**kg CO2 / MMBtu**	**kg CO_2 / gallon**
Ethanol	0.084	68.44	5.749
Biodiesel	0.128	73.84	9.452
Rendered Animal Fat	0.125	71.06	8.883
Vegetable Oil	0.120	81.55	9.786

Table A.8. CO2 Electricity Emission Factors

eGRID subregion acronym	eGRID subregion name	Annual output emission rates	
		(lb CO_2/MWh)	(metric ton CO_2/MWh)
AKGD	ASCC Alaska Grid	1,256.87	0.570
AKMS	ASCC Miscellaneous	448.57	0.203
AZNM	WECC Southwest	1,177.61	0.534
CAMX	WECC California	610.82	0.277
ERCT	ERCOT All	1,218.17	0.553
FRCC	FRCC All	1,196.71	0.543
HIMS	HICC Miscellaneous	1,330.16	0.603
HIOA	HICC Oahu	1,621.86	0.736
MROE	MRO East	1,610.80	0.731
MROW	MRO West	1,536.36	0.697
NEWE	NPCC New England	722.07	0.328
NWPP	WECC Northwest	842.58	0.382
NYCW	NPCC NYC/Westchester	622.42	0.282
NYLI	NPCC Long Island	1,336.11	0.606
NYUP	NPCC Upstate NY	545.79	0.248
RFCE	RFC East	1,001.72	0.454
RFCM	RFC Michigan	1,629.38	0.739
RFCW	RFC West	1,503.47	0.682
RMPA	WECC Rockies	1,896.74	0.860
SPNO	SPP North	1,799.45	0.816
SPSO	SPP South	1,580.60	0.717
SRMV	SERC Mississippi Valley	1,029.82	0.467
SRMW	SERC Midwest	1,810.83	0.821
SRSO	SERC South	1,354.09	0.614
SRTV	SERC Tennessee Valley	1,389.20	0.630
SRVC	SERC Virginia/Carolina	1,073.65	0.487

Table A.9. Volatile Solids Removed Through Solids Separation

Type of Solids Separation	Volatile Solids Removed (fraction)
Gravity	0.45
Mechanical:	
Stationary screen	0.17
Vibrating screen	0.15
Screw press	0.25
Centrifuge	0.50
Roller drum	0.25
Belt press/screen	0.50

Table A.10. Baseline Assumptions for Greenfield Projects

Baseline Assumption	Dairy Cattle Operations		Swine Operations
	>200 Mature Dairy Cows	<200 Mature Dairy Cows	
Anaerobic manure storage system	Flush system into an anaerobic lagoon with >30 day retention time	Flush system into an anaerobic lagoon with >30 day retention time	Flush system into an anaerobic lagoon with >30 day retention time
Non-anaerobic manure storage system(s)	Solids storage	Solids Storage	Solids Storage
MS_L	90% lagoon 10% solids storage	50% lagoon 50% solids storage	95% lagoon 5% solids storage
Lagoon cleaning schedule	Annually, in September	Annually, in September	Annually, in September

Appendix B Data Substitution – Quantification Methodology

The methodology presented below may be used only for missing or non-quality assured methane concentration parameters or for missing or non-quality assured flow metering parameters.

(a) The data substitution methodology in table B.1 is allowed for limited circumstances where a project encounters flow rate or methane concentration data gaps that are discrete, limited, non-chronic, and due to unforeseen circumstances.

- (1) Data substitution can only be applied to methane concentration *or* flow readings, but not both simultaneously, except as noted in table B.1.
- (2) Substitution may only occur when two other monitored parameters corroborate and document proper functioning of the destruction device and system operation within normal ranges, except as noted in table B.1.
  - (A) Proper functioning of the destruction device can be documented by thermocouple readings for flares or engines, energy output for engines, etc.
  - (B) For methane concentration substitution, flow rates during the data gap must be consistent with normal operation.
  - (C) For flow rate substitution, methane concentrations during the data gap must be consistent with normal operations.
  - (D) If corroborating parameters fail to meet any of these requirements, no substitution may be employed.

(b) The data substitution methodology in table B.1 is required for all circumstances where a projects encounters project flow rate or methane concentration gaps.

(c) Data substitution is not permissible for equipment that monitors operation of destruction devices and a BDE of 0% must be used for all periods where the operation of the destruction device is not assured.

Table B.1. Missing Data

Duration of Missing Data	Substitution Methodology
Less than six hours of one parameter	Use the average of the four hours immediately before and following the outage.
Six to 24 hours of one parameter	Use the 90% lower or upper confidence limit of the 24 hours prior to and after the outage, whichever results in greater conservativeness.
One to seven days of one parameter	Use the 95% lower or upper confidence limit of the 72 hours prior to and after the outage, whichever results in greater conservativeness.
One quarter of methane concentration data	Use the highest or lowest value for the other three quarters of methane concentration data, whichever results in greater conservativeness. This may only be applied once per reporting period.
Greater than one week of one parameter or any time with more than one parameter	Take a zero BDE for the device(s) in question with missing data and use the 99% lower or upper confidence limit of all available valid data for the reporting period, whichever results in greater conservativeness. If less than 25% of the data for the reporting period is available, then the single highest or lowest data point must be used.