U.S. Soil Enrichment

Protocol | Version 1.1 | May 31, 2022

CLIMATE ACTION RESERVE

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Soil Enrichment Protocol

Reducing emissions and enhancing soil carbon sequestration on agricultural lands

Version 1.1

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Abbreviations and Acronyms

CO_2	Carbon dioxide
CO_2e	Carbon dioxide equivalent
CH_4	Methane
CRT	Climate Reserve Tonne
dm	Dry matter
GHG	Greenhouse gas
N_2O	Nitrous oxide
NRCS	USDA Natural Resources Conservation Service
Reserve	Climate Action Reserve
SEP	Soil Enrichment Protocol (this document)
SOC	Soil organic carbon
SSR	Source, sink, and reservoir
t	Metric ton (or tonne)
USDA	U.S. Department of Agriculture

1 Introduction

The Climate Action Reserve (Reserve) Soil Enrichment Protocol (SEP) provides guidance to account for, report, and verify greenhouse gas (GHG) emission reductions associated with projects which reduce emissions and enhance soil carbon sequestration on agricultural lands through the adoption of sustainable agricultural land management activities.

The Climate Action Reserve is an environmental nonprofit organization that promotes and fosters the reduction of greenhouse gas (GHG) emissions through credible market-based policies and solutions. A pioneer in carbon accounting, the Reserve serves as an approved Offset Project Registry (OPR) for the State of California's Cap-and-Trade Program and plays an integral role in supporting the issuance and administration of compliance offsets. The Reserve also establishes high quality standards for offset projects in the North American voluntary carbon market and operates a transparent, publicly accessible registry for carbon credits generated under its standards.

Project developers that initiate soil enrichment 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[1] and Section 8 of this protocol.

This protocol is designed to ensure the complete, consistent, transparent, accurate, and conservative quantification and verification of GHG emission reductions associated with a soil enrichment project.[2]

[1] Available at http://www.climateactionreserve.org/how/verification/verification-program-manual/.
[2] See the WRI/WBCSD GHG Protocol for Project Accounting (Part I, Chapter 4) for a description of GHG reduction project accounting principles.

2 The GHG Reduction Project

2.1 Background

Agricultural lands have the ability to both emit and sequester carbon dioxide (CO_2), the primary GHG responsible for human-caused climate change (IPCC, 2014). Annual and perennial plants, 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 grow and respire, some of this carbon is deposited in the soil as root exudates. As plants die and regrow, some of this carbon is also deposited in the soil as particulate matter. This carbon cycling occurs throughout the year, with positive and negative fluxes over time depending on soil conditions, climatic conditions, management practices, and other variables.

Depending on how agricultural lands 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, agricultural lands may have a net negative or net positive impact on the climate, depending on their characteristics and management. Globally, agriculture, forestry, and other land use sectors contribute up to 24% of total GHG emissions (IPCC, 2014). Agriculture alone accounts for 9% of all GHG emissions in the U.S. (U.S. EPA, 2020). Through sustainable management and protection, agricultural lands can play a positive and significant role to help address global climate change. This protocol is designed to take advantage of agricultural lands' unique capacity to sequester, store, and emit CO_2 and to facilitate the positive role that these lands can play to address climate change.

In addition, agricultural land management activities are a source of GHG emissions separate from the fluxes of the SOC pool. Activities such as equipment use, fertilizer application, residue management, and livestock grazing management cause emissions of CO_2, CH_4, and N_2O. Changes to these practices can lead to reductions in these emissions, as well as impacts to the flux of CO_2 in the soil.

Soil enrichment activities encompass an enormous variety of practices, with tremendous potential for development of new practices. This approach to farming is intended to restore the health of the soil over time, through continuous and adaptive practice change, rebuilding losses due to conventional agricultural practices. This protocol focuses on outcomes in terms of net GHG flux, and project participants are able to apply the most appropriate practices for their given situation.

2.2 Project Definition

For the purpose of this protocol, the GHG reduction project is defined as the adoption of agricultural management practices that are intended to increase soil organic carbon (SOC) storage and/or decrease net emissions of CO_2, CH_4, and N_2O from agricultural operations, as compared to the baseline. Soil enrichment projects must be located on land which is, as of the project start date, cropland or grassland (including managed rangeland and/or pastureland), and which remains in agricultural production throughout the crediting period. Projects shall not include areas which have been cleared of native ecosystems or other restored or protected areas (i.e., restored grassland) within the 10 years prior to the project start date. Project activities must not decrease carbon stocks in woody perennials on the project area. Projects should not introduce broadscale organic amendments to grasslands, because of the potential to shift systems towards lower grassland biodiversity, by excessively increasing nutrients in the system.

While there is no lower limit to the size of a SEP project, either in land area, number of fields, or number of Field Managers, it is recognized that the approaches employed in this protocol, in the context of currently existing data and technology, are best-suited to large-scale projects. The challenges for small-scale projects will be apparent when considering the fixed costs of project development, as well as application of the uncertainty requirements in Appendix D. It is anticipated that small-scale projects will become more feasible over time as more data are collected and improvements are made to models, tools, and technologies.

2.2.1 Defining the Project Activities

Project activities are those activities that are necessary for the implementation and maintenance of one or more new agricultural land management practices which are reasonably expected (over the project crediting period) to increase SOC storage and/or reduce emissions of CO_2, CH_4, and/or N_2O from agricultural land management activities. SOC storage and GHG emissions in the project scenario are compared against a baseline scenario, which assumes that, in the absence of the project, the baseline land management activities would have been continued. Project activities must not result in long-term material decreases in carbon stocks in woody perennials on the project area, but the removal of small volumes of woody biomass (such as the removal of trees along fence rows) is allowed. Projects that employ some controls for woody species encroachment into grasslands will remain eligible, provided similar controls were present in the baseline.

Land management practices considered for soil enrichment projects include those which result in one or more changes to:

- Fertilizer (organic or inorganic) application; and/or,
- The application of soil amendments (organic or inorganic); and/or,
- Water management/irrigation; and/or,
- Tillage and/or residue management; and/or,
- Crop planting and harvesting (e.g., crop rotations, cover crops); and/or,
- Fossil fuel usage; and/or,
- Grazing practices and emissions.

This list above is intended to be indicative of activities that (i) could foreseeably contribute to GHG emission reductions, and (ii) the impacts of which could foreseeably be modeled using this protocol.

If grazing is employed in the project scenario, the livestock manure must not be managed in liquid form within the project area (i.e., containing less than 20% dry matter and subject to active management), and grazing activities must meet the criteria in Section 6.3.

Eligibility of project activities is described in more detail in Section 3.4.1. Guidance for assessing and accounting for potential emissions leakage due to soil enrichment project activities is provided in Section 5.5.

2.2.2 Defining the Project Area

For the purposes of this protocol, the project area is defined as an eligible field or fields on which eligible project activities occur. Fields should be configured to exclude areas that do not meet the requirements set out below (for instance, the field boundary should be drawn to exclude areas containing Histosol soils, as those are ineligible). Fields that are split by minor breaks consisting of ineligible areas (i.e., fields split by roads, tree breaks, hedgerows, or watercourses) can still be considered a single field, if desired.

The project area must adhere to the following criteria:

- Each field must be clearly delineated.
- The area within each field must be continuous (except minor breaks, as noted above).
- The same crop (or crop mix) must be grown throughout each field within a reporting period.
- Permanent or improved roads, watercourses[3], and other physical boundaries must be excluded (i.e., such areas will not be included in project area acreage).
- The project area shall not contain any Histosols.[4]
- The project may contain tile-drained fields or surface drainage, as long as such features were present on the project field before the project start date (i.e., not installed for the purposes of the project).
- If the project area includes land classified as highly erodible land (HEL),[5] that land must meet federal Highly Erodible Land Conservation provisions to be eligible under this protocol.
- If the project area includes land classified as wetlands,[6] that land must meet federal Wetlands Conservation provisions[7] to be eligible under this protocol.
- Projects may not include areas which have been cleared of native ecosystems, including established and restored grasslands, within the 10 years prior to the project start date. The prohibition on clearing native ecosystems does not include the removal of a small numbers of trees, such as the removal of trees along fence rows that is immaterial respective to project emission reductions.

For fields identified as HEL or wetlands, project developers must demonstrate the requisite regulations are being followed. One means for doing so is to provide proof that USDA HEL/wetlands certification has been applied for the given field.[8] This simplified means for identifying HEL or wetlands does not excuse any field from regulatory compliance requirements.

[3] Ephemeral field lands are not required to be excluded, so long as they do not remain in the same location permanently.
[4] Histosols are found at all altitudes, but the vast majority occurs in lowlands. Common names are peat soils, muck soils, and bog soils. See USDA-NRCS, Keys to Soil Taxonomy. Available at https://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/survey/class/taxonomy/?cid=nrcs142p2_053580.
[5] Highly erodible land is defined as "land that has an erodibility index of 8 or more" in Title 7 of the Code of Federal Regulations, Subpart A, Part 12.2. Part 12.21 further outlines how HEL is identified and how the erodibility index is calculated.
[6] Wetlands generally have a predominance of hydric soil and are inundated or saturated by surface or groundwater for various durations over the year. See Title 7 of the Code of Federal Regulations, Subpart A, Part 12.2 for the definition of wetlands. It is also worth noting that wetlands in the project area may also be impacted by the applicability conditions in Section 2.2 of this protocol.
[7] As outlined in Title 7 of the Code of Federal Regulations, Subpart A, Part 12.5(b), and in Section 510.10 of the National Food Security Act Manual. Such exemptions may include wetlands farmed prior to 1985, wetlands with minimal effect, or wetlands with mitigation measures in place.
[8] As of the time of adoption of this protocol, the USDA required producers to use USDA Form AD1026 to apply for HEL / wetland certification. Project developers should request a copy of this form, and provide the same to their verifier. USDA Form AD1026 can be downloaded from the USDA website here: https://www.farmers.gov/sites/default/files/documents/Form-AD1026-Highly-Erodible-Land.pdf.

2.2.3 Project Aggregation

Individual soil enrichment projects may group together multiple fields and/or Field Managers into one larger, aggregated, or grouped, project. An aggregated project shall be considered to be a single "project" everywhere that this document uses that term. Aggregated projects are subject to the following conditions:

- There is no absolute minimum or maximum size for a field or an individual Field Manager's fields to be included in the project
- The entire project must share a common Project Owner, as defined in Section 2.3.1.

2.2.3.1 Entering an Aggregated Project

Individual fields may join a project by being added to the project's Project Submittal form (if joining a project at initiation) or by being added through the Field Enrollment & Transfer form (if joining once the project is underway). New fields begin crediting at field start date or project-start date, depending on which is later.

The project developer managing the project that receives the new fields will be responsible for submitting the Field Enrollment & Transfer form, listing the field(s) that are now joining their project, as well as updating a list of enrolled fields contained within the form. Projects may alternatively seek Reserve approval to have all enrolled fields listed in an alternative format (such as in a digital database). Emission reductions occurring on new fields entering a project may start counting toward the project's CRTs in the reporting period during which the field joined the project. Emission reductions will be reported as a single combined project for the reporting period in which the transfer occurred. Any period of time that has already been reported and verified under a single project will not be included in reporting under the newly combined project.

Each field will only be eligible for the duration of its own crediting period, regardless of the point in time at which it joins the aggregated project. All fields in a project must use the same version of this protocol, and if a field from one project joins another project, then the newest version of the protocol in use between them must be adopted for the newly combined project.

Projects that have already been submitted to the Reserve may choose to join another existing project by submitting a Field Enrollment & Transfer form.

2.2.3.2 Transferring Fields Between Projects

Fields must meet the requirements in this section in order to change projects or leave to become their own project and continue reporting emission reductions to the Reserve. In all cases, emission reductions must be attributed to one project for a complete reporting period, as defined in Section 0, and no CRTs may be claimed by a project for a field that does not participate and report data for a full reporting period. Reporting for each field must be continuous to remain participating and avoid termination, regardless whether transferring to another existing project or leaving to establish a new project. 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.[9] Project activities on an individual field may be terminated and the field may be removed from the project at any time, pursuant to the requirements of Section 3.5.

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

In order for a field or fields to leave a project and join another existing project, the project developer for the receiving project must submit a Field Enrollment & Transfer form to the Reserve, noting that it is a “field transfer” and identifying the project from which it transferred, and the project to which it is being transferred. Reporting under the destination project shall continue according to the guidance in Section 7. Upon the successful transfer of a field into a new project, the project from which the field is transferred will not need to conduct ongoing monitoring for sequestered carbon on the given field, as long as the new project undertakes monitoring for reversals.

For fields that leave a project to become a separate 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 7.3. The project must submit either a monitoring report or verification report (whichever is due) by this new deadline in order to keep the project active with the Reserve. The project developer setting up the new project will need to submit a Project Submittal form to the Reserve to initiate the new project.

2.3 Project Ownership Structures and Terminology

Soil enrichment projects will generally involve several parties playing different roles. This section outlines key participants and the ownership structures allowed for soil enrichment projects.

Table 2.1. Summary of Project Ownership Categories

Term	Definition	Required Participant?
Landowner	The entity with title to the physical property that contains one or more fields within the project area.	No
Field Manager	The entity with management control over agricultural management activities for one or more fields within the project area.	Yes
Project Developer	An entity which manages the monitoring, reporting, and verification, including interaction with the online registry.	Yes
Project Owner	The entity with legal ownership of the GHG reduction rights for the entire project area.	Yes
Aggregator	A Project Owner whose project contains multiple Field Managers.	No

In the table above, any of the defined entities could be the Project Owner. In an aggregated project, one of the Field Managers could be the Project Owner and the aggregator, or those roles may be filled by a third party. In any case, the project developer may be a contracted third-party (i.e., a technical consultant).

2.3.1 The Landowner and the Field Manager

The term “landowner” is not given special meaning for this protocol beyond the commonly understood meaning of the word. There is no requirement for direct participation of the landowner or for production of land title documentation. For the purposes of this protocol, the term “Field Manager” is defined in Section 2.3. Every project will involve at least one Field Manager. A soil enrichment project is defined in relation to management of a specific area of land, and thus the project activities are attributed to the Field Manager for that field. Unless there exists a legal instrument transferring the ownership rights to the GHG emission reductions to an entity other than the Field Manager, the Field Manager is assumed to be the Project Owner for the relevant field(s). Field Managers may, however, transfer ownership of the GHG reduction rights to a third party.

The project developer must be able to identify the land title holder for any given field if requested by the verifier or the Reserve. Project developers are encouraged to ensure the land title holder has been fully informed about the SEP project on their land, and has contractually assented to the SEP project. To include the land title holders in project related contractual arrangements could lower risks to the project and the program as a whole. However, the express inclusion of land title holders in project-related contractual arrangements is not strictly required by the protocol, and is not something that needs to be verified.

2.3.2 The Project Owner

Every project will have a single Project Owner. CRTs will only be issued to the Reserve account of the Project Owner, and, as such, the Project Owner must maintain an active account on the Reserve in order to receive such issuance(s). The Project Owner must have clear ownership of the project's GHG reductions during the period covered by the Project Implementation Agreement (Section 3.5.3). The Project Owner may be the Field Manager or a third-party entity who has a signed contract with the Field Manager conveying title to the GHG reduction rights related to the relevant field(s). In the case of third-party ownership, the ownership of the GHG reductions must be established by clear and explicit contracts. The Project Owner must attest to such ownership by signing the Reserve's Attestation of Title form.[10] The Project Owner shall execute the Project Implementation Agreement (PIA). 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 (e.g., a technical consultant).

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 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, by signing the Attestation of Title described above. 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. The Reserve will not issue CRTs for GHG reductions or sequestration that is reported or claimed by entities other than the Project Owner (e.g., the landowner for a field where the Field Manager is a lessee). Attestations must be signed by the Project Owner.

The intent with the guidance above is to ensure that the GHG emission reductions inherent in all offsets issued to the project are not expressly double counted anywhere else, by any other party. The intent here is not to restrict claims relating to broader or more general positive impacts of these projects, including any non-GHG impacts hopefully recognized in accordance with the guidance in Section 2.4 on Non-GHG Impacts of Project Activities. Parties are

[10] Attestation of Title form available at http://www.climateactionreserve.org/how/program/documents/.

encouraged to consult the Reserve regarding any questions associated with how best to recognize GHG or non-GHG impacts associated with SEP projects.

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 to manage the flow of documents and information to the Reserve. The scope of services provided by a technical consultant 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.

2.4 Non-GHG Impacts of Project Activities

The Soil Enrichment Protocol (this document) is intended to credit for GHG emission reductions and enhanced soil carbon sequestration on agricultural lands, through the adoption of sustainable agricultural land management activities. Natural working lands that are managed for agricultural purposes, regardless of location or management, are subject to forces that could degrade ecosystem services such as water quality, biodiversity, and degrading soil organic carbon and microbiome diversity. This protocol relies primarily on existing laws and regulatory programs to ensure community standards for such issues are met. The regulatory compliance requirements in Section 3.6 set out guidance for ensuring no laws are broken, including laws relating to broader non-GHG impacts of projects. When registering a project, the project developer must attest that the project was in material compliance with all applicable laws, including environmental regulations, during the verification period. The project developer is also required to disclose any and all instances of non-compliance – material or otherwise – of the project with any law to the Reserve and the verification body.

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 ecosystem services. Whilst the sustainable agricultural land management practices eligible and encouraged under this protocol are expected to achieve beneficial GHG impacts on the project area (see Section 2.1), the project developer should nonetheless take care and all reasonable precautions to ensure no broader harms are caused by the project. Since eligible practices should constitute an overall improvement relative to historical management, it is unlikely that the project activity will result in significant negative non-GHG impacts. Nevertheless, the Reserve urges project developers to describe any significant impacts (positive or negative) that their GHG projects will have on other environmental issues such as air and water quality, endangered species and natural resource protection, and environmental justice.

The intent with this guidance is to encourage parties to better highlight the ways in which their projects positively or negatively affect such goals and, where potential negative environmental and socio-economic impacts are identified, describe the steps that have been, or will be, taken to mitigate and/or monitor them. In particular, the Reserve encourages project developers to report on the potential environmental co-benefits of their projects, such as reductions in other air pollutants, improvements in water quality, enhancement of wildlife habitat, etc. One example of co-benefits the Reserve would like to recognize is the significant contributions made by farmers who have already begun to implement such sustainable agricultural practices. The pioneering work done by farmers in adopting such practices has and will continue to be instrumental in demonstrating to other farmers what is possible and profitable. Whilst it is not always possible for offset protocols to recognize such critical early action, via crediting for the associated emission reduction impacts, due to additionality concerns, it would be entirely appropriate for project developers to voluntarily recognize such early action as part of their optional accounting of the co-benefits associated with their projects. It should be noted that the Reserve has been approved as an official provider of offsets for the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA), to voluntarily abate emissions from international aviation.[11] In order to be potentially eligible to supply offsets to CORSIA, each project must report on co-benefits, in accordance with guidance enshrined in the latest version of the Reserve Offset Program Manual.[12]

The guidance in this section does not create any specific obligations for a project to demonstrate, and a verifier to verify, that projects are not undermining progress with respect to these broader non-GHG goals.

[11] The scope of the initial program approval in March 2020 did not include protocols which were not yet adopted by the Reserve. Thus, as of this writing, this protocol is not eligible for use in CORSIA. The Reserve will pursue expansion of the scope of its approval to include this protocol.
[12] A copy of the latest version of the Reserve Offset Program Manual can be downloaded from the Reserve website at: http://www.climateactionreserve.org/how/program/program-manual/.

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.

Section 3.1	Location	⟶	*U.S. and its tribal lands and territories*
Section 3.2	Project Start Date	⟶	*No more than 12 months prior to project submission*
Section 0	Project Crediting Period	⟶	*The period over which emission reductions can be credited (10 years per field, renewable up to 2 times, up to 30 years)*
Section 3.4	Additionality	⟶ ⟶	*Meet performance standard* *Exceed regulatory requirements*
Section 3.5	Permanence	⟶	*One hundred years following the issuance of CRTs, or employing tonne-year accounting or an alternative mechanism for ensuring permanence*
Section 3.6	Regulatory Compliance	⟶	*Compliance with all applicable laws*

3.1 Location

Only projects located on non-federal lands in the United States, U.S. territories, and on U.S. tribal lands are eligible to register with the Reserve. See Section 2.2.3 for guidance on what constituted eligible project areas.

3.2 Project Start Date

The project start date is defined as the first day of the cultivation cycle during which the eligible practice change was adopted. For aggregated projects, the start date is set in relation to each individual field. Thus, the start date of an aggregated project is defined by the earliest field start date in the project (which would be the earliest first day of a cultivation cycle during which an eligible practice was adopted). Every other field in an aggregated project must have a start date after the project start date.

To be eligible, new projects must be submitted to the Reserve no more than 24 months after the project start date for a year following the adoption of Version 1.1. After this time period, new projects must be submitted 12 months of the project start date. Projects may 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 Reserve Offset Program Manual.

New fields may be added to projects within 24 months of a field's start date for a year following the adoption of Version 1.1. After this time period, new fields may be added if submitted within 12 months after the field start date. See Section 7.2 for details regarding defining the cultivation cycle.

For pre-existing projects (those submitted to the Reserve during the 12-month period following the adoption of Version 1.0 of the protocol), any project with a start date defined by a cultivation cycle that begins in 2018 and does not end prior to September 30, 2018, is eligible. New fields may be added to “pre-existing projects” within 24 months of a field’s start date for a year following the adoption of Version 1.1. After this time period, new fields may be added if submitted within 12 months after the field start date.

3.3 Project Crediting Period

The crediting period for projects under this protocol is 10 years, renewable up to two times, for a potential total of 30 years of crediting. For aggregated projects, the crediting period is assessed at the individual field level, meaning each field may only be credited for up to 10 years, renewable up to two times for a total potential of 30 years of crediting. The overall project, however, may earn credits for greater than 10 or even 30 years. Projects, or individual fields, may choose to end their crediting period earlier than 10 years, subject to the requirements for permanence (Section 3.5). The crediting period for this protocol is renewable up to two times, for a potential total crediting period of 30 years. The project must pass eligibility requirements of the most recent version of this protocol, including any updates to the performance standard test (see Section 3.4.1 below) in order to be granted a renewed crediting period. If an individual field is seeking a renewed crediting period, while a remaining portion of the fields in the project continue to report under a prior version of the protocol, the field seeking the renewed crediting period must pass the eligibility requirements in the most recent version of this protocol. However, if it is determined that the field remains eligible, it may continue reporting under the version of the protocol being used for the remainder of the project. Adoption of additional new practice changes during the project lifetime does not alter the crediting period for a field.

However, the Reserve will cease to issue CRTs for any given eligible practice(s) if at any point in the future, the practice(s) become legally required, as defined by the terms of the legal requirement test (see Section 3.4.2). Thus, the Reserve will issue CRTs for GHG reductions quantified and verified according to this protocol for a maximum of 10 years for each given field, (renewable up to two times for a total potential crediting of 30 years) after the project start date, or until the project activity is required by law. Where an eligible practice becomes mandated by law, fields are still eligible to receive credits for other practices, so long as the baseline is updated to reflect the now-mandatory practice going forward.

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

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
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 Soil Enrichment projects, established by this protocol.

This protocol uses a two-stage *common practice* additionality assessment. The first stage involves the application of a *negative list* of specific activities, in specific parts of the country, which are deemed to be non-additional by default. The second stage allows projects to use project-specific measures to demonstrate any parts of a project identified as being non-additional by default according to the *negative list* to be deemed additional.

The performance standard test is applied at the field level, at the time when a project applies for registration with the Reserve, and each time a new field is brought into a project. Additionality for a SEP project is demonstrated by the adoption, at the project start date, of one or more changes in pre-existing agricultural management practices that are reasonably expected (over the project crediting period) to increase SOC storage and/or reduce emissions of CO_2, CH_4, and/or N_2O from agricultural land management activities. Adoption is defined as a change from a baseline management scenario to a project management scenario, and may involve either implementation of a new activity (e.g., introducing cover crops), cessation of a pre-existing activity (e.g., tillage), significant adjustment of a pre-existing activity (e.g., reduced N application rate), or some combination thereof. This may be a simple practice change, such as the addition of cover crops, or it may be a more complex practice change, such as the introduction of a new crop into a multi-year rotation, or increasing the diversity of the species used for a cover crop.

Practice changes may be qualitative (e.g., adding a cover crop into the crop rotation) or quantitative (e.g., reducing the nitrogen fertilizer application rate). In any case, to be eligible for a SEP project, the change must be of a type and magnitude which is able to be quantified using the modeling approach selected for the reporting period. A change in practice includes adoption of a new practice (e.g., adoption of one of the illustrative regenerative agriculture practices listed in Appendix B), cessation of a pre-existing practice (e.g., stop tillage or irrigation) or adjustment to a pre-existing practice (e.g., reduction in N application rate). In any case, the magnitude of the practice change must be such that a reasonable person, knowing the context of the baseline scenario in the relevant region, would consider it to be a new management practice. Additional information regarding the Performance Standard Test can be found in Appendix A.

3.4.1.1 Performance Standard Test – Negative List

Some of the broad suite of practices that are potentially eligible to generate credits under this protocol already have significant uptake rates in certain parts of the country. In particular, data available at the time of protocol development indicate that no-tillage, reduced-tillage, cover crop adoption, rotational grazing and intensive grazing have high adoption rates in certain counties. These practices, when adopted in isolation on a given field (i.e., only one new eligible practice is adopted on the given field), will be considered to be on a *negative list* of activities that will be considered non-additional, and thus ineligible by default, when adopted in counties with an uptake rate of more than 50% of either total cropland area, or total pasture operations (for cropping or grazing respectively). The county-level eligibility of screened practices is presented in the accompanying *SEP Additionality Tool*.[13] This tool will be updated periodically by the Reserve, as new data becomes available. The adoption of any other single practice that is not found on this *negative list*, as identified within the *SEP Additionality Tool*, is eligible to generate credits. Any project that is solely adopting single practice changes in nitrogen management should use the Reserve's Nitrogen Management Protocol V2.0 and are ineligible under this protocol.

[13] The *SEP Additionality Tool* is available on the Soil Enrichment Protocol webpage at: http://www.climateactionreserve.org/how/protocols/soil-enrichment/.

3.4.1.2 Performance Standard Test – Project-Specific Means to Demonstrate Additionality

Despite the determination of a given practice as being ineligible by default during the first performance standard test stage, project owners have the opportunity to demonstrate the additionality of such practices. Practices implemented on a field and deemed ineligible by default at its start date are considered additional if any of the following conditions are met:

1. ***Stacking multiple eligible practices:***
    a. A combination of two or more eligible practices are implemented during the initial year of reporting, notwithstanding any such individual practice being on the *negative list*.
    b. A single practice that is on the *negative list* is initially implemented but:
        i. at least one other eligible practice is implemented before the end of the 3rd year following its start date in which case credits will be issued at the point of adopting the further practice(s) based on increased SOC and/or emission reductions achieved by the single practice adopted initially in addition to those achieved by the implementation of a further eligible practice(s). In other words, fields that fall into this category will have to wait until they add an additional eligible practice before they can then get credited, but they will be issued credits earned as of their start date. A field will be allowed to have up to 3 reporting periods of single practice adoption, before they must include a further eligible practice.
        ii. at least one other eligible practice is implemented after the first 3 years but within its first crediting period, in which case the field will be able to retain its start date and baseline and be able to generate credits starting from the reporting period when that project adopts a further eligible practice(s).

2. ***Demonstrating new tillage practices are still rotated with conventional tillage:*** As an alternative to stacking multiple eligible practices, projects may submit a project-specific analysis to justify the additionality of fields that are implementing tillage activities that are on the *negative list.* Projects must base their methodology on regional data or circumstances, and/or local expert opinion, taking into consideration circumstances during the given historical baseline period. To use this option, projects must demonstrate that the given tillage practice, although prevalent in a given county, is typically rotated with conventional tillage, over short timespans (3 to 4 years or less) based on one of the following approaches:

    1. The assessment must provide evidence, possibly including through the use of remotely-sensed data, to indicate that the majority of fields in the county in which the subject field is located have either implemented conventional tillage, or a rotation of no-till or reduced-tillage with conventional tillage, during the historical baseline period; or
    2. The assessment must include expert opinion that the majority of fields in the county in which the subject field is located have either implemented conventional tillage, or a rotation of no-till or reduced-tillage with conventional tillage, during the historical baseline period. If relying on a rotation of tillage practices, the project must also identify at least three actively-cultivated fields in the same county that have been rotating the given tillage practice with

conventional tillage, with the individual acreage of each field being no less than the acreage of the project field in question.

The rotation between conventional tillage and new tillage practices would override the expected SOC benefits, and thus a project that implements new tillage practices under the conditions of this protocol would be going beyond common practice in the given region, and would generate additional climate benefits.

3.4.1.3 Defining the Baseline Scenario

To assess how a project performs relative to a performance threshold, a baseline scenario must first be established. The baseline scenario assumes the continuation of pre-project agricultural management practices. For each sample unit (e.g., field), practices applied in the baseline scenario are determined by defining an historical baseline period during which crop rotation and management practices will be illustrated. The length of the historical period shall be no less than three years, and shall at least be long enough to encompass a complete rotation of crops and management practices, unless a complete rotation extends beyond five years (e.g., if the same crop is grown every year, but the field is only tilled every four years, the historical period must be at least four years). If a baseline rotation extends beyond five years, then the minimum baseline period is five years. However, projects may always extend the historical period farther back in time, if desired, or if required by the model being used. The minimum length of the historical baseline period may ultimately be determined by data requirements for the model chosen to model baseline emissions (see Section 5.1 for guidance on baseline quantification). A longer historical baseline period is always preferable and encouraged, even if it encompasses multiple rotations of similar management practices, as this will enhance the ability of the baseline modeling to account for the long-term trends due to baseline practices.

Figure 3.1, below, illustrates several potential baseline crop rotation scenarios. For each scenario, A, B, and C, the figure notes the full length of the most recent rotation, as well as the number of years of historical data needed to complete the baseline modeling for each crop in the project scenario Example A shows how a field with a monocropping system would capture three “rotations” to satisfy the minimum requirement for three years. Example B shows how a field with a two-year rotation would have a historical baseline period of four years, satisfying both the three-year minimum, as well as the need to capture complete rotations. Example C shows that a field with a five-year crop rotation would only need to consider one full rotation.

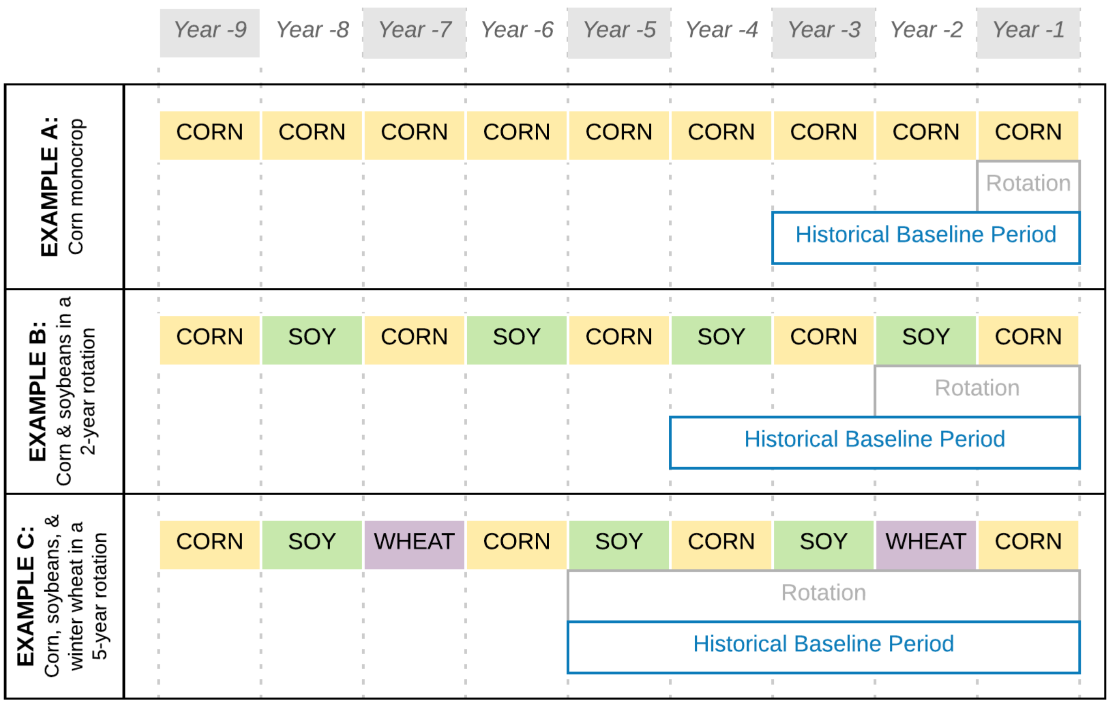

Figure 3.1. Examples for Defining the Historical Crop Rotation and Baseline Period

3.4.1.4 Modeling the Baseline

Historical data will be input into a model (or models) in order to estimate baseline SOC and GHG emissions. Different models may require slightly different inputs, and the historical baseline period is used to set a pattern of crop cultivation activity and determine how many years of data are necessary (see Section 5.1 for guidance on baseline quantification). For projects using biogeochemical models, the historical period is used to determine the appropriate inputs for the modeling of the baseline and project scenarios in the first cultivation cycle of the project. Regardless which type of model is used, data from the historical period are used in order to model the baseline changes in pools and sources for which the project is employing the use of models. In this case, the selection of which years of data are to be simulated and averaged together to determine the baseline are set according to the guidance below.

As described above, the historical baseline period establishes a pattern of crop cultivation, by including a full rotation of crops and management practices. That pattern of cultivation is staggered across parallel baseline threads equivalent to the number of years in the historical baseline period (see Step 2 of Figure 3.2). Such threads are maintained throughout the crediting period. This is done because it's the most appropriate means to model conditions as they evolve over the years. For each cultivation cycle of the crediting period, the project developer must define the counterfactual baseline scenario in a way that most appropriately compares the project scenario against what would have happened in the absence of the project activities. In other words, if project crop rotation continues to match baseline crop rotation, then the baseline will reflect this, in order to provide a "like-to-like" comparison. However, this is not possible if the project activities involve changes to the baseline rotation of crop and management activities. This protocol allows for two different baseline modeling approaches, depending on whether the activities in the reporting period match those in the historical baseline period:

1. **Matched Baseline**

A matched baseline indicates that there is parity between project crop rotation and baseline crop rotation, as established by the historical baseline period described in Section 3.4.1.3. This approach may be applied for as long as the project continues the same crop rotation as existed in the historical baseline period. The matched baseline may also be used if, in the baseline scenario, the field would have been fallow, but a crop is grown in the project scenario. A matched baseline means that in the current project year, the model will be used to simulate cultivation of this same crop, using baseline management practices. This simulation is done using the weather from the current project year, and the outputs from the model are used to determine the baseline SOC stock change and emissions. If the current year's crop matches with the same crop in more than one of the parallel baseline threads, then the matched baseline is an average of the results for those threads for that year.

2. **Blended Baseline**
   A blended baseline indicates that the baseline scenario represents all possible cultivation options represented in the historical baseline period averaged together. The blended baseline approach may be used if the project developer prefers, or if the matched approach cannot be employed because the reporting period individual choice of crop no longer matches the historical baseline rotation of crops, then this blended approach is used. A blended baseline means that in the current reporting period, the model will be used to individually simulate every year from the historical baseline period, regardless of crop. As with the matched approach, these simulations are done using the weather from the current project year, and the outputs from the model are averaged together to determine the baseline SOC stock change and emissions. The baseline simulations are continuous, meaning in the next cultivation cycle the individual baseline simulations will continue with whatever is the next cultivation cycle from the historical baseline period. The number of simulations corresponds to the number of cultivation cycles in the historical baseline period, with the pattern staggered such that each simulation covers one complete baseline cultivation cycle in every year of the project (Figure 3.2).

Figure 3.2 provides guidance for determining whether a project should use the matched or blended baseline approach for various change cases.

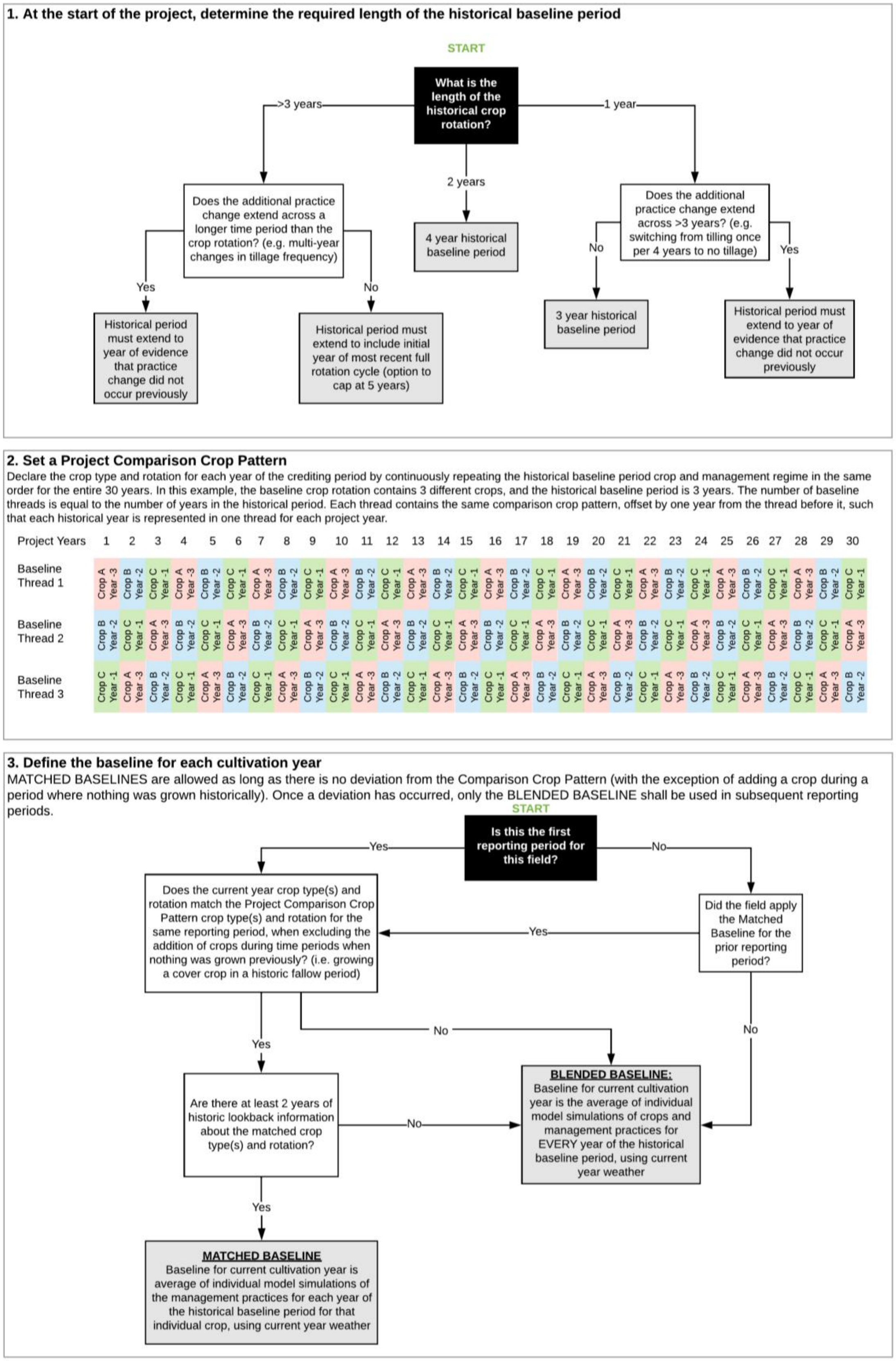

Figure 3.2. Baseline Setting Process and Decision Tree

3.4.1.5 Data Collection for Activities in the Baseline Scenario

For each sample unit, a schedule of activities in the baseline scenario will be determined by assessment of practices implemented during the *x* crop years prior to the project start date where *x* is the historical baseline period (being at least one complete rotation of crops and management practices), defined in Section 3.4.1.3. The data used to define this historical period must be collected according to the guidance in Section 6.1.

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.

To satisfy the legal requirement test, Project Owners must submit a signed Attestation of Voluntary Implementation form[14] prior to the commencement of verification activities each time the project is verified (see Section 8). In addition, the project's Monitoring Plan (Section 6) must include procedures that the Project Owner will follow to ascertain and demonstrate that the project at all times passes the legal requirement test.

3.4.3 Ecosystem Services 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 (Cooley & Olander, 2011). 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.

Generally speaking, the Reserve does not prohibit either payment or credit stacking, under this protocol, unless such payments or credits are specifically delineated per tCO_2e. Guidance and approval must be sought from the Reserve regarding any possible stacking of payments or credits with soil enrichment projects. 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.

3.4.3.1 Credit Stacking

The Reserve did not identify any active mitigation credit market opportunities which would impact soil enrichment projects. Potential opportunities exist, however, which should be monitored over time and assessed as they mature and become available for overlap with soil enrichment projects. These potential opportunities include carbon sequestration tax credits, water quality trading programs, water quantity trading programs, and non-GHG impact certifications.

3.4.3.2 Payment Stacking

The Reserve has identified two general types of payments that support the project activities being credited under this protocol: "landscape-scale" payments and "enhancement" payments.

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

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,[15] but it 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 pastureland 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.

Given that soil enrichment projects are crediting based on changes to land management practices, rather than avoided conversion, these landscape-scale payment programs do not pose a concern.

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 it would impact project eligibility.

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 those authorized by the Farm Bill and administered by the USDA Natural Resources Conservation Service (NRCS).[16]

The practices that are compensated for by the programs mentioned above are based on minimum, standardized definitions, and do not require monitoring and reporting on GHG benefits. Payments are tied to activity, but not performance. Because of this, Field Managers 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.

3.5 Requirements for Permanence

The Reserve requires that credited reversible GHG reductions and removals be effectively "permanent" in order to serve as valid offset credits. For the purposes of this protocol, a reversible 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 or issued credits proportional to the 100-year permanence timeframe, as described in Section 3.5.5. For example, if CRTs are issued to a soil enrichment project in year 24 following its start date, soil carbon in the project area must be maintained for 100 years, through at least year 124. An emission reduction is considered reversible if it is related to carbon which remains

[15] Environmental Quality Incentives Program: 7 CFR §1466.36; CSP, 7 CFR §1470.37.
[16] More information on Farm Bill programs administered by the NRCS may be found at https://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/farmbill/.

stored in a carbon pool, such as soil organic carbon, but could be released back into the atmosphere under certain conditions. An example of a nonreversible emission reduction on a soil enrichment project would be the avoided N_2O emissions related to baseline fertilizer use. Furthermore, once an emission reduction is considered permanent, it is no longer considered reversible.

To meet this requirement, Project Owners must put in place sufficient mechanisms to effectively monitor and report on the status of a soil enrichment 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 or the project opts to be issued credits based on a tonne-year accounting basis (see Section 3.5.5). Unless the Reserve approves the use of an alternative mechanism to maintain permanence, failure to maintain ongoing monitoring and reporting may result in the automatic termination of the project. Note that this means that monitoring and reporting for a project may be required to 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" (see Section 3.5.4).

The Reserve ensures the permanence of GHG reductions and removals through four mechanisms:

1. ***Monitoring and verification of reversals:*** The requirement for all Project Owners to monitor for potential reversals of soil organic carbon, submit regular monitoring reports, and submit to regular third-party verification of those reports (as detailed in Sections 6 through 8 of this protocol) for the duration of the crediting period and permanence period, unless an alternative mechanism is approved.
2. ***Use of Project Implementation Agreement (PIA):*** The requirement for all Project Owners (except those using tonne-year accounting in lieu of other permanence mechanisms) to sign a Project Implementation Agreement with the Reserve, described below in Section 3.5.3, which obligates Project Owners to supply CRTs to compensate for reversals of GHG reductions and removals for a set period of time.
3. ***Buffer Pool Contributions:*** The maintenance of a Buffer Pool to provide insurance against reversals of GHG reductions and removals due to unavoidable causes (see Sections 3.5.2 and 5.3.1).
4. ***Use of Tonne-Year Accounting (TYA):*** The optional application of tonne-year accounting, in combination with or in lieu of the other permanence mechanisms (see Section 3.5.5).

3.5.1 Defining Reversals

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. Regardless of the area of impact had by a reversal, permanence will be assessed at the project level, rather than the individual field level. Decreases of SOC on individual fields will not affect permanence, so long as the project as a whole has had a stable or increasing SOC pool over the relevant time period.

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, flooding or drought. 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. These unavoidable reversals are compensated for by the Buffer Pool, as described in Section 5.3.2.2.

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 3.5.3, 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 required 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, sustained increase in tillage, eminent domain, or mining or drilling activities. 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 Field Managers' or Project Owner's negligence, gross negligence, or intentional mismanagement of the project area as agricultural land.

Avoidable reversals must be communicated to the Reserve and compensated for by the Project Owner, as prescribed in Section 5.3.2.1

3.5.2 About the Buffer Pool

The Buffer Pool is a holding account for CRTs from sequestration-based projects, which is administered by the Reserve. All soil enrichment projects must contribute a percentage of CRTs to the Buffer Pool any time they are issued CRTs for verified GHG reductions and removals. Each project's contribution is determined by a project-specific risk rating, as described in Section 5.3.1. If a project experiences an unavoidable reversal of GHG reductions and removals (as defined in Section 5.3.2), the Reserve will retire a number of CRTs from the Buffer Pool equal to the total amount of carbon that was reversed (measured in metric tons of CO_2e). The Buffer Pool therefore acts as a general insurance mechanism against unavoidable reversals for all soil enrichment registered with the Reserve. Management and disposition of the Buffer Pool is described in the Reserve Offset Program Manual.

3.5.3 Project Implementation Agreement

Permanence obligations are guaranteed through a legal agreement that obligates the Project Owner to conduct monitoring activities on the project area for a defined period, and to compensate for avoidable reversals that occur during the permanence commitment, typically the 100-year period following CRT issuance (unless a project employs tonne-year accounting or receives approval for a shorter commitment through other safeguards). For soil enrichment projects, this agreement is known as the Project Implementation Agreement. Requirements for monitoring and reporting activities during the permanence period are detailed in Section 7.3.

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 Soil Enrichment 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 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 risk of financial failure of the Project Owner, and therefore the Reserve's ability to act on the terms of the PIA, is factored into the project's Buffer Pool contribution, as described in Section 5.3.1.

The PIA does not restrict the transferability of the specific CRTs issued, but does hold the Project Owner to the compensation requirements of Section 5.3.2. By the terms of the PIA, the contract is satisfied upon the Project Owner's full performance of the requirements of this protocol. 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. The PIA for soil enrichment projects is not a public document.

Upon request, the Reserve may approve a mechanism to compensate for reversals as an alternative to a PIA, such as a surety bond. The use of such alternative financial mechanisms during the crediting period reduces the required buffer pool contribution related to the risk of financial failure, as described in Section 5.3.1. The Reserve must review and approve alternative financial mechanisms before they may be used.

The length of any PIA may be selected by the Project Owner at the time of its execution. However, if the term of enforcement of the PIA is less than 100 years following CRT issuance, then one of the following must occur to avoid the finding of a complete reversal at the end of the contract term:

1. The PIA is extended, with the Project Owner accepting further obligations for monitoring and reporting for reversals. PIAs that are shorter than 100 years would continually need to be extended, until the sum total of all the PIAs met or exceeded 100 years in duration;
2. The Project Owner receives written approval from the Reserve for an alternative mechanism for compensating for reversals. Any such alternative would need to remain in place for 100 years; or
3. The Project Owner elects to be issued credits based on tonne-year accounting (see Section 3.5.5), with credit issuance based on the tonne-year values associated with the length of the term of enforcement of the PIA.

3.5.4 Permanence Period

When the crediting period for a field has concluded, the field enters a "permanence period" until the minimum time commitment is met. During this time, the field must continue to be monitored to demonstrate that a reversal has not occurred. This may be accomplished remotely and must follow the requirements in Section 6.2. If monitoring requirements are not met, the Reserve will consider this to be an avoidable reversal, which must be compensated for by the Project Owner.

With the exception of Project Owners that choose to use the tonne-year accounting approach, if a field opts out of the program prior to the end of its crediting period, the Project Owner must choose one of two options:

1. Consider CRTs issued based on GHG removals from the field to be automatically reversed. Depending on the number of fields exiting the program, this may not cause a reversal for the project, since reversal compensation is assessed at the project level; or
2. The field automatically enters the permanence period, following the monitoring and reporting procedures outlined in Section 7.6.

3.5.5 Tonne-Year Accounting

Real, additional reductions of atmospheric CO_2 are realized immediately when CO_2 is sequestered in a carbon pool at levels beyond "business as usual." However, that sequestered CO_2 completely mitigates an equal GHG emission elsewhere only when it is maintained out of the atmosphere for at least 100 years. In the event a Project Owner does not commit to the storage of reversible carbon stocks for 100 years, permanence of the emission reductions will be achieved by the application of tonne-year accounting (TYA). Any credits issued pursuant to *optional* use of a tonne-year accounting approach will only ever be issued on an ex-post basis, and must still meet the same rigorous requirements for permanence as all other sequestration related credits. The usefulness of a tonne-year accounting approach lies in a reduction in the permanence period, in exchange for a proportionate reduction in the volume of credits issued.

Whereas tonne-tonne accounting (TTA) recognizes the entire climate benefit of a permanently sequestered tonne of CO_2 by issuing one credit for each tonne of CO_2 sequestered and maintained for 100 years, tonne-year accounting (TYA) recognizes the time-value of CO_2 held out of the atmosphere for time periods less than the full commitment period of 100 years. Thus, even if additional sequestered CO_2 is maintained for less than 100 years, credits can be issued as a proportion of the 100-year permanence timeframe achieved. Under this protocol, credits are recognized under TYA at a rate of 1 percent per tonne of CO_2e per year. Projects electing to employ the TYA option do not need to meet the 100-year commitment described in the preceding sections, but will be issued fewer credits, based on the length of the commitment. After their commitment period (as defined by the terms of their PIA) ends, these projects will not be required to maintain ongoing monitoring for reversals, unless they elect to extend their commitment for an additional period of time.

Crediting for reversible emission reductions will be based on the remaining length of the permanence commitment compared to the vintage year of the credits. For example, if a project executes a PIA with a term of 20 years subsequent to the first reporting period, credits for reversible emission reductions will be issued on the following schedule in Table 3.1 (assuming the permanence commitment is never renewed or extended).

Table 3.1. Schedule for Issuance of Reversible Emission Reduction Credits Under 20-Year PIA

Project Year	Percentage of Current Year Emission Reductions for which Credits are to be Issued upon Successful Verification = 1% + Remaining Length of PIA
1	21%
2	20%
3 - 20	19% - 2%[17]
21	1%
22 - 30	1%

This schedule may be altered by amending the existing PIA or executing a new PIA. See Section 5.3, Equation 5.2.B, and Box 5.2 for guidance on determining the appropriate basis for credit issuance for a given reporting period based on the length of the commitment under the PIA. Requirements for reversals are only applicable within the commitment period.

Projects employing TYA with no PIA (i.e., only being credited 1 percent per additionally sequestered tonne of CO_2e maintained each year) are not required to contribute to the buffer pool, though their monitoring and verification obligations remain through the end of the crediting period.

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 Owners must submit a signed Attestation of Regulatory Compliance form[18] 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, or that are in any way related to the project fields. Verifiers are in turn required to disclose any such violations in writing to the Reserve. In order to avoid delays in crediting, all such violations should be reported to the Reserve at the earliest possible time.

The Reserve will determine that a violation is to be considered to have been “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 the Reserve 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. The Reserve will 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.

[17] Each subsequent year after year 3 receives 1% less than the previous year. For example, on year 4 the issuance is 18% of total emission reductions, on year 5 it is 17%, and so on. This reflects that the contractual commitment established after the completion of year one is diminishing over time and, with that, the proportion of emission reductions that can be issued up front.
[18] Attestation forms are available at http://www.climateactionreserve.org/how/program/documents/.

4 The GHG Assessment Boundary

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

Figure 4.1 illustrates all relevant GHG SSRs associated with soil enrichment 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.

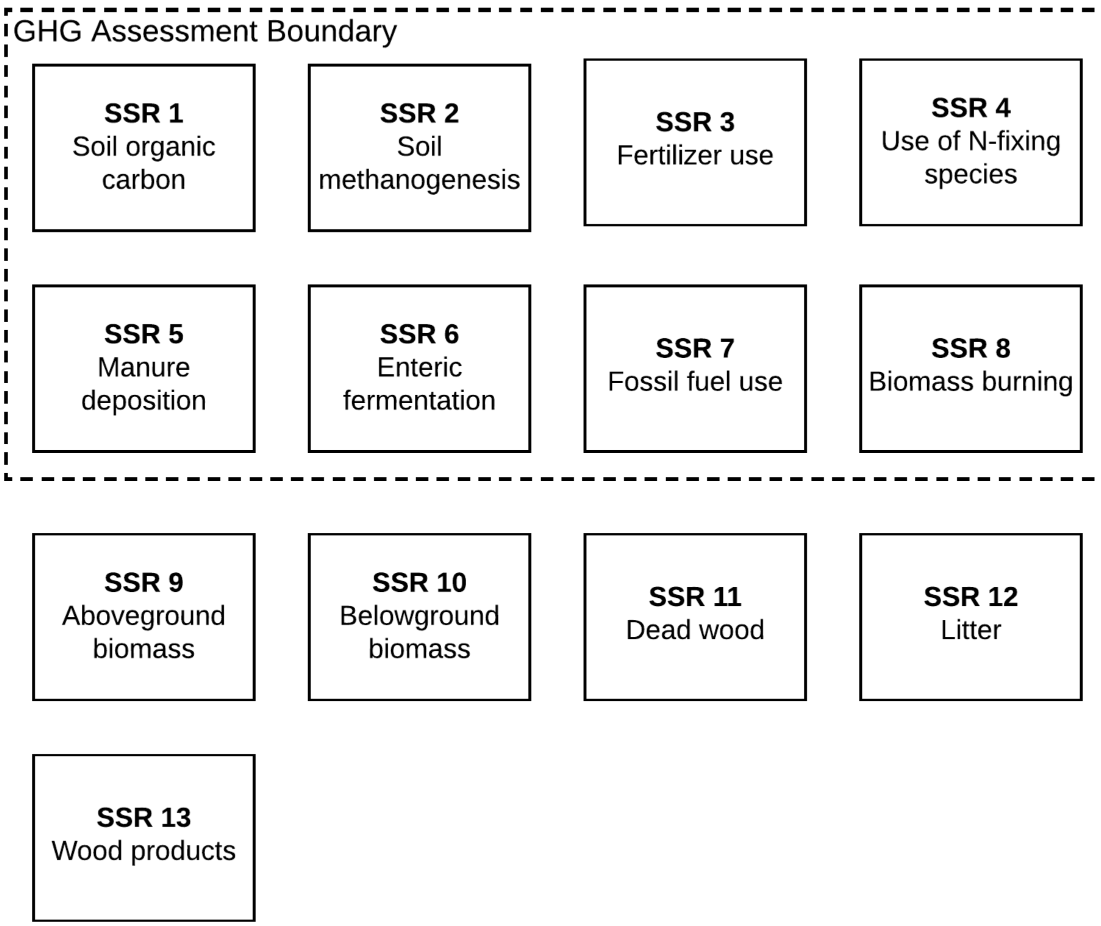

Figure 4.1. General Illustration of the GHG Assessment Boundary
All SSRs are relevant in both the baseline and project scenarios.

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

SSR	Source Description	Gas / Element	Included (I) or Excluded (E)	Quantification Method	Baseline (B) or Project (P)	Justification/Explanation
1	Soil organic carbon	C	I	Modeled and measured	B,P	Major carbon pool affected by the project activity that is expected to increase in the project scenario.
2	Soil methanogenesis	CH_4	I	Modeled	B,P	Must be included where the project activity may significantly increase emissions compared to the baseline and may be included where the project activity may reduce emissions compared to the baseline.
3	Fertilizer use	N_2O	I	Modeled or calculated	B,P	If synthetic and/or organic nitrogen fertilizers are applied in the project or baseline scenarios, N_2O emissions from nitrogen fertilizers must be included in the project boundary.
4	Use of nitrogen fixing species	N_2O	I	Modeled or calculated	B,P	If nitrogen fixing species are planted in the project or baseline scenario, N_2O emissions from nitrogen fixing species must be included in the project boundary.
5	Manure deposition	CH_4 N_2O	I	Modeled or calculated	B,P	If livestock grazing occurs in the project or baseline scenario, CH_4 and N_2O emissions from manure shall be included in the project boundary. Included emissions are those from manure applied to the land directly by livestock or applied to the land from storage, but not those from manure in storage.
6	Enteric fermentation	CH_4	I	Modeled or calculated	B,P	If livestock grazing occurs in the project or baseline scenario, CH_4 emissions from enteric fermentation shall be included in the project boundary.
7	Fossil fuel use	CO_2	I	Calculated	B,P	Fossil fuel emissions from vehicles and equipment may increase or decrease in the project scenario, depending on practice changes.
8	Biomass burning	CH_4 N_2O	I	Modeled or calculated	B,P	Must be included where the project activity may significantly increase emissions compared to the baseline and may be included where the project activity may reduce emissions compared to the baseline.

SSR	Source Description	Gas / Element	Included (I) or Excluded (E)	Quantification Method	Baseline (B) or Project (P)	Justification/Explanation
9	Aboveground biomass	C	E	N/A	N/A	This pool is not expected to experience significant changes in the project scenario.
10	Belowground biomass	C	E	N/A	N/A	Conservatively excluded, as project activities are likely to increase C stocks in this pool.
11	Dead wood	C	E	N/A	N/A	This pool is not expected to experience significant changes in the project scenario.
12	Litter	C	E	N/A	N/A	This pool is not expected to experience significant changes in the project scenario.
13	Wood products	C	E	N/A	N/A	This pool is not expected to experience significant changes in the project scenario.

5 Quantifying GHG Emission Reductions

GHG emission reductions from a soil enrichment project are quantified by comparing modeled and calculated project and baseline emissions, as well as from calculating changes in SOC. Baseline soil organic carbon stocks are an estimate of the soil organic carbon pool in the baseline scenario, while baseline GHG emissions are accounted for from sources within the GHG Assessment Boundary (see Section 4) that would have occurred in the absence of the project. Project emissions are increases in soil organic carbon sequestration and changes in actual GHG emissions that occur at sources within the GHG Assessment Boundary, credited as the difference in the soil organic carbon pool between the project and baseline scenarios, as well as any net change in emissions (i.e., project emissions must be subtracted from the baseline emissions to quantify the project's net GHG emission reductions for each individual source and gas). The net GHG emission reductions are then summed separately for reversible and non-reversible sources. The length of time over which GHG emission reductions are periodically quantified and reported is called the "reporting period." GHG emission reductions must be quantified and verified for each reporting period (see Section 7.2). In certain cases, a single reporting period may contain more than one cultivation cycle.

Table 5.1. Global Warming Potentials for Non-CO_2 Greenhouse Gases

Greenhouse Gas	100-year Global Warming Potential[19]
CH_4	25
N_2O	298

The protocol provides a flexible approach to quantifying emission reductions and removals resulting from the adoption of new agricultural management practices in the project compared to the baseline. Baseline and project emissions are defined in terms of flux of CH_4, and N_2O and net flux of CO_2 in units of metric tons CO_2e per unit area per reporting period. Approaches to quantification of contributing sources for CO_2, CH_4, and N_2O are listed in Table 5.2. Where more than one quantification approach is identified for a given source/pool, projects have the choice of approach, so long as the same approach is used in the baseline and project scenarios.

Soil organic carbon levels must be directly measured in relation to the initiation of the project, as well as at least every five years thereafter. Using this directly measured SOC input, projects must model their baseline SOC stock change (as well as, optionally, CH_4, and N_2O emissions) during each cultivation cycle of the crediting period. Baseline emissions will be remodeled each year using climate data from the project cultivation cycle, following the guidance in Section 5.1. With respect to reporting period (or 'project scenario') emissions, the SOC component must be "trued-up" at least every 5 years using direct measurements. For projects using models to estimate project scenario SOC stocks, the subsequent direct SOC measurement would be used in the same manner as in the first year of the project, as the input to the model simulation for that year. The output SOC stock from that simulation would then be compared to the output SOC stock from the simulation of the prior cultivation cycle to determine the SOC stock change, and thereby incorporating the adjustment for the direct measurement. All other sources, sinks,

[19] As of this writing, the Reserve relies on values for global warming potential (GWP) of non-CO_2 GHGs published in the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (2007). The values relevant for this protocol are provided in Table 5.1. These values are to be used for all soil enrichment projects unless and until the Reserve issues written guidance to the contrary. IPCC 4AR is available here: https://www.ipcc.ch/publications_and_data/publications_and_data_reports.shtml.

and reservoirs (SSRs, see Section 4 for guidance on SSRs) can be quantified each year using either default equations and emission factors or modeling (as detailed in Table 5.2). In all other intervening years where direct measurement of SOC is not employed, the SOC component can also optionally be quantified using a modeling approach. In reporting periods where direct measurement is employed, if the direct measurement reveals SOC levels for a given field below the previously modeled project scenario SOC for that field, that field will contribute a negative stock change to the overall project quantification for that reporting period. In this way, the measurement method will provide for a reconciliation or ‘true-up’ between the modeled and measured approaches. If the net SOC stock change across the entire project area for a reporting period is found to be negative, this would result in a reversal.

Project Owners must have a Monitoring Plan identifying how direct measurements and modeling are employed in relation to the fulfillment of all project quantification, monitoring, and reporting requirements, as outlined in Section 6.

Table 5.2. Acceptable Quantification Approaches by Source and Gas

GHG	Source	**Modeled** (external to protocol equations)	Directly Measured	Calculated
CO_2	Soil organic carbon	**X**	**X**	
	Fossil fuel use			**X**
CH_4	Methanogenesis	**X**		
	Enteric fermentation	**X**		**X**
	Manure deposition	**X**		**X**
	Biomass burning			**X**
N_2O	Nitrification/denitrification	**X**		**X**
	Manure deposition	**X**		**X**
	Biomass burning			**X**

A typical project will conduct soil sampling at the point new fields are brought into the project (possibly using a model to adjust the SOC measurements backward to the project start date). Those SOC measurements will then form the basis of both the baseline and project scenario modeling for the first cultivation cycle. As shown in Table 5.2, the model may be used only for SOC stocks, or it may also be used to simulate CH_4 and N_2O emissions from methanogenesis, enteric fermentation, manure deposition, and nitrification/denitrification. The project developer may choose instead to use project data to quantify those sources of CH_4 and N_2O using the equations in this protocol and their relevant default emission factors. However, the same approach must be used in both the baseline and project scenarios and must be consistent across an entire project for a given reporting period.

For example, if a project elected to use modeling to the fullest extent possible, the first two years would employ the activities in Table 5.3. The baseline scenario always pairs historical data with current weather, while the project scenario always pairs current project data with current weather.

Table 5.3. Example Quantification Approach with Maximal Use of Modeling

	Starting SOC	SOC Change	CH_4 (except burning)	CH_4 (burning only)	N_2O (except burning)	N_2O (burning only)	CO_2 from Fossil Fuels
Year 1 Baseline	Measured	Modeled	Modeled	Default equations	Modeled	Default equations	Default equations
Year 1 Project		Modeled	Modeled	Default equations	Modeled	Default equations	Default equations
Year 2 Baseline	Modeled	Modeled	Modeled	Default equations	Modeled	Default equations	Default equations
Year 3 Project	Modeled	Modeled	Modeled	Default equations	Modeled	Default equations	Default equations

Figure 5.1, below, illustrates the basic inputs and quantification approaches for the first five years of a project which elects to use modeling to the *maximum* extent allowed by this protocol.

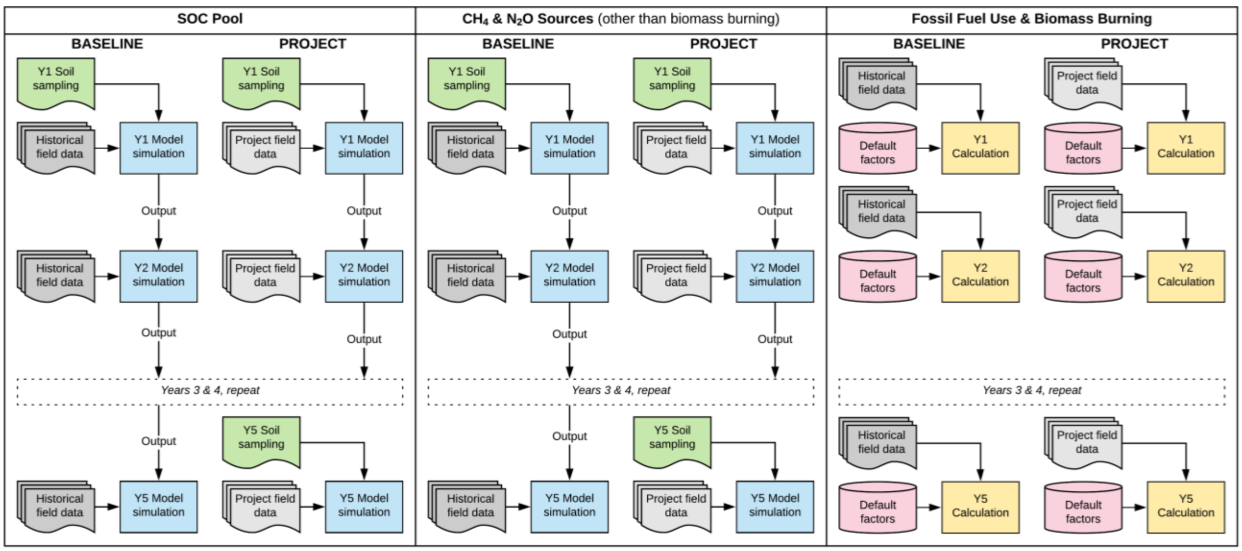

Figure 5.1. Example Data and Process Flow with Maximal Use of Modeling

Alternatively, if a project elected to use modeling to the *least* extent possible, the first two years would employ the activities in Table 5.4. The baseline scenario always pairs historical data with current weather, while the project scenario always pairs current project data with current weather.

Table 5.4. Example Quantification Approach with Minimal Use of Modeling

	Starting SOC	SOC Change	CH_4 (except methanogenesis)	N_2O	CO_2 from Fossil Fuels
Year 1 Baseline	Measured	Modeled	Default equations	Default equations	Default equations
Year 1 Project	Measured	Modeled	Default equations	Default equations	Default equations
Year 2 Baseline	Modeled	Modeled	Default equations	Default equations	Default equations
Year 3 Project	Modeled	Modeled	Default equations	Default equations	Default equations

Figure 5.2, below, illustrates the basic inputs and quantification approaches for the first five years of a project which elects to use modeling to the *least* extent possible under this protocol. For situations where a project uses a different combination of models and default equations, the basic information displayed in these examples remains the same.

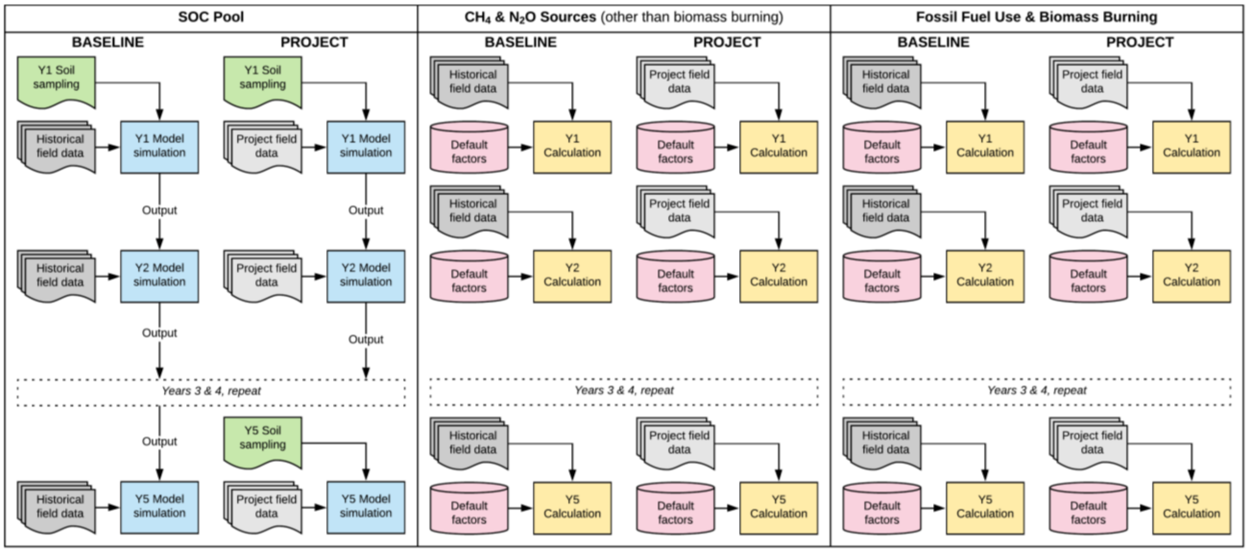

Figure 5.2. Example Data and Process Flow with Minimal Use of Modeling

Figure 5.3 provides a general view of the equations used to quantify soil enrichment projects. As described above, this protocol allows flexibility for quantification of certain gases and pools. The SOC pool must always be either directly measured or modeled. Other sources may be either modeled or calculated using Tier 2 equations in this protocol, as described below. This illustrates the top-level concepts, while the sections below contain more detailed maps of equations.

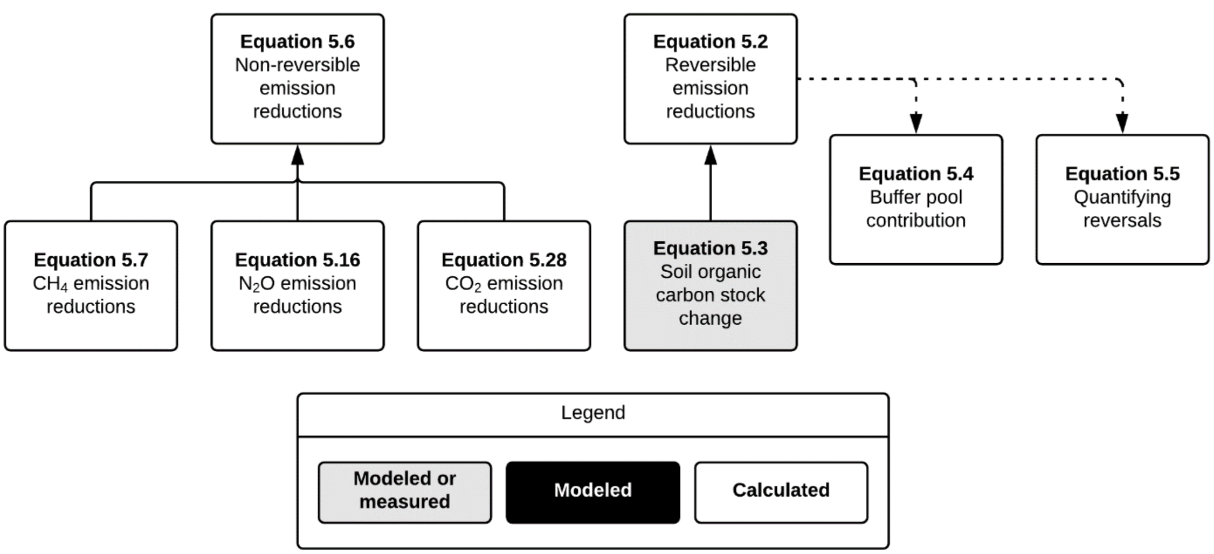

Figure 5.3. Map of Equations to Quantify SEP Projects

The quantification approach in this protocol is designed to accommodate different statistical sampling approaches for the use of directly measured soil data. The project Monitoring Plan shall provide the definition of “sample unit” as it pertains to the project (e.g., sample point, pixel, field, farm, etc.). The definition of “sample unit” should also address the use of stratification. Stratification should consider such components as crop type, rotation, climate, soil, topography, geography, and management practices. Where the sample unit is contained with a field, but certain data (e.g., practices, weather) are collected for the entire field, those data may be applied to all units within the relevant field. For quantification using direct measurement or modeling, results for each sample unit within a stratum will be averaged together and then applied to the total area of the stratum.

For simplification, quantification steps that must be aggregated are specified to do so per stratum. However, it is recognized that projects could be designed in such a way that quantification is aggregated at a lower level prior to aggregation to the stratum level. In other cases, quantification could occur at field level and be aggregated directly to the project level, without consideration of stratification. For example, grazing emissions may be quantified at the field level before being aggregated across the stratum. In addition, the use of models may occur at each soil sampling point. The process of aggregating must always accurately account for the relevant areas and time periods. In some cases, this could involve weighting or pro-rating in order to accurately apply across the stratum , or to accurately determine field-level results from higher-order (e.g., project or stratum) totals. For project designs where some or all of the quantification occurs at the point, stratum, or project level (without first occurring at the field level), it is necessary to allocate reversible and non-reversible emission reductions back to the field level for purposes of quantifying reversals and assigning vintages. Such allocation may use stratum averages or approaches that are more locally accurate, such as verified model runs on similar fields. Verifiers shall confirm that field-level results sum correctly to the project level, and that the allocation approach results in reasonable estimates at the field level.

This protocol distinguishes between emission reductions which are reversible (i.e., related to carbon stored in the soil organic carbon pool) and those which are non-reversible (i.e., related to avoided emissions from cultivation activities). Reversible emission reductions are quantified according to Equation 5.2. The permanence requirements of Sections 3.5 and 5.3 apply only to the reversible emission reductions. The non-reversible emission reductions are quantified according to Section 5.4, and are considered permanent at the time of issuance.

Projects will conduct soil sampling and, thus, quantification based on a sub-set of the total project area, known as a sample. Section 6.5 discusses the sample design. In order to apply the results of the quantification of sample units across the entire project area requires the use of averages. The average emission reductions for a sample unit is multiplied by the number of acres in that sample unit. This conceptual approach to using averages in the quantification is described in Box 5.1.

Box 5.1. Target Parameter: Average Emission Reductions of All Gases and Pools

Our target parameter is the total emissions reduction of all gases and pools across the project during the reporting period. To estimate this quantity, subdivide the area of interest into a set of spatial units of equal area (such as pixels of land) and denote the reduction in emissions of gas or pool $\boldsymbol{G}$ during time period t at spatial unit i as

$$\Delta \boldsymbol{G}_{\boldsymbol{t},\boldsymbol{i}} \equiv \boldsymbol{G}_{\boldsymbol{bsl},\boldsymbol{t},\boldsymbol{i}} - \boldsymbol{G}_{\boldsymbol{pr},\boldsymbol{t},\boldsymbol{i}}$$

where the operator Δ takes the difference between the baseline ("bsl") and project ("pr") emissions to the atmosphere of gas or pool G. The units of $\Delta G_{t,i}$ are tons CO_2e per acre per year.

The goal is to estimate the average of $\Delta G_{t,i}$ across all spatial units i, denoted by $\overline{\Delta G_t}$, and then to sum those averages across all gases:

$$\overline{\boldsymbol{ER}_{\boldsymbol{t}}} = \sum_{\text{gases } \boldsymbol{G}} \overline{\Delta \boldsymbol{G}_{\boldsymbol{t}}}$$

These averages are estimated using measurements and model simulations on a random subset of the spatial units i. Those estimates are denoted by $\widehat{\overline{\Delta G_t}}$ and $\widehat{\overline{ER_t}}$, and details on those estimates and the associated uncertainty are in Appendix D.

At the final step, the estimated average emissions reduction $\widehat{\overline{ER_t}}$ is multiplied by the area and duration of the reporting period to arrive at an estimate of emissions reduction in tons of CO_2e. For the purposes of crediting by vintages (emission reductions created per calendar year), projects with reporting periods that are not aligned with calendar years (from January 1st to December 31 of a given year) shall have their credits prorated by the number of days in each calendar year covered in the reporting period.

5.1 Modeling the Baseline

For soil enrichment projects, the baseline shall be modeled for each cultivation cycle of the crediting period based upon the baseline approach defined in Section 3.4.1.3. For each sample field, a schedule of activities in the baseline scenario will be determined by assessment of practices implemented during the historical baseline period. The interval over which practices are assessed, *x* cultivation cycles, should conform to the specifications described in Section 3.4.1.3.

The baseline SOC and GHG emissions levels shall then be determined by employing the selected model to create simulations that combine historical management practices with project weather and consider current year crop type for the project following the guidelines described in Section 3.4.1.3. This approach aims to capture the sensitivity of soil processes to actual project weather conditions and crop-specific management. For each cultivation cycle of the project, following minimum data guidelines described in Section 3.4.1.3, historical practices for each crop will be modeled with the selected model, driving the simulation of historical years of practices with weather for that year (i.e., the same weather data should be used to model the baseline as well as the additional practice).

Rather than modeling the baseline for a project once at the beginning of the project (or upon entry of each field within an aggregate), baseline modeling is conducted for each cultivation cycle, throughout the duration of the project's crediting period(s). For each reporting period, the baseline is modeled for that reporting period only and not for future reporting periods. Thus, a project comprising one field is expected to undertake 30 separate baseline modeling exercises (one for each reporting period – assuming the project continues for the potential three 10 year crediting periods), while a project comprising multiple fields should expect to undertake 30 separate baseline modeling exercises for each sample field.

For the SOC pool baseline in project year 1, assuming the project is growing corn in both the baseline and project scenarios (i.e., following the matched baseline approach), the calculation is as follows in Table 5.5.

Table 5.5. Example Matched Baseline SOC Modeling for the First Three Reporting Periods

Model Run	Model Start	Weather	Crop & Management	Result
Model run B.1	Measured SOC	Project Year 1	Corn Year -3	Sim_{-3}
BASELINE ∆SOC YEAR 1				$\boldsymbol{Sim_{-3,SOC}}$
Model run B.2	$Sim_{-3,SOC}$	Project Year 2	Corn Year -2	Sim_{-2}
BASELINE ∆SOC YEAR 2				$\boldsymbol{Sim_{-2,SOC}}$
Model run B.3	$Sim_{-2,SOC}$	Project Year 3	Corn Year -1	Sim_{-1}
BASELINE ∆SOC YEAR 3				$\boldsymbol{Sim_{-1,SOC}}$

For the SOC pool project value in project year 1, the calculation is as follows in Table 5.6.

Table 5.6. Example Project Scenario SOC Modeling for the First Three Reporting Periods

Year 1	Model Start	Weather	Crop & Management	Result
Model run P.1	Measured SOC	Year 1	Year 1	Sim_1
PROJECT ∆SOC YEAR 1				$\boldsymbol{Sim_1}$
Model run P.2	Sim_1	Year 2	Year 2	Sim_2
PROJECT ∆SOC YEAR 2				$\boldsymbol{Sim_2}$
Model run P.3	Sim_2	Year 3	Year 3	Sim_3
PROJECT ∆SOC YEAR 3				$\boldsymbol{Sim_3}$

In each year, the SOC stock change is calculated as the difference between the project result and the baseline result for that year. If SOC is directly measured in that year, then the directly measured value will represent the input to that year's modeling (unless the project is *only* quantifying project scenario SOC stock changes through direct measurement).

For modeling the baseline in a subsequent year, the baseline results from the prior year are used as the input SOC value, as shown below.

For the SOC pool baseline in project year 2, assuming that the project introduces a third crop into what was previously a two-year corn-soybean rotation, per the guidance in Figure 3.2 (i.e., a blended baseline approach), the calculation is as follows in Table 5.7.

Table 5.7. Example Blended Baseline SOC Modeling for Subsequent Reporting Periods

Year 2	Model Start	Weather	Crop & Management	Result
Model run B.2-1	$Sim_{B.1-1}$	Year 2	Corn Year -4	$Sim_{B.2-1}$
Model run B.2-2	$Sim_{B.1-2}$	Year 2	Soybean Year -3	$Sim_{B.2-2}$
Model run B.2-3	$Sim_{B.1-3}$	Year 2	Corn Year -2	$Sim_{B.2-3}$
Model run B.2-4	$Sim_{B.1-4}$	Year 2	Soybean Year -1	$Sim_{B.2-4}$
BASELINE ∆SOC YEAR 2				**Average($Sim_{B.2-1}$, $Sim_{B.2-2}$, $Sim_{B.2-3}$, $Sim_{B.2-4}$)**
Model run B.3-1	$Sim_{B.2-1}$	Year 3	Soybean Year -3	$Sim_{B.3-1}$
Model run B.3-2	$Sim_{B.2-2}$	Year 3	Corn Year -2	$Sim_{B.3-2}$
Model run B.3-3	$Sim_{B.2-3}$	Year 3	Soybean Year -1	$Sim_{B.3-3}$
Model run B.3-4	$Sim_{B.2-4}$	Year 3	Corn Year -4	$Sim_{B.3-4}$
BASELINE ∆SOC YEAR 3				**Average($Sim_{B.3-1}$, $Sim_{B.3-2}$, $Sim_{B.3-3}$, $Sim_{B.3-4}$)**

For modeling of CH_4 and N_2O, the approach is exactly the same. For projects employing biogeochemical models, the SOC value is used as a model input exactly as laid out in the tables above. For projects using the default factor-based equations in this protocol to quantify the baseline, the SOC stock is not a relevant input. In those cases, however, the approach is the same: the equations are run once for each cultivation cycle in the historic baseline period, with the results used according to either the matched baseline approach or the blended baseline approach, as applicable.

For the CH_4 and N_2O baseline in the first three reporting periods (assuming the matched baseline approach), the calculation is as follows in Table 5.8.

Table 5.8. Example Matched Baseline CH_4 and N_2O Modeling for First Three Reporting Periods

Model Run	Model Start	Weather	Crop & Management	Result
Model run B.1	Measured SOC	Project Year 1	Corn Year -3	Sim_{-3}
BASELINE ∆GHG YEAR 1				$\boldsymbol{Sim_{-3,N2O,CH4}}$
Model run B.2	$Sim_{-1,SOC}$	Project Year 2	Corn Year -2	Sim_{-2}
BASELINE ∆GHG YEAR 2				$\boldsymbol{Sim_{-2,\ N2O,CH4}}$
Model run B.3	$Sim_{-2,SOC}$	Project Year 3	Corn Year -1	Sim_{-1}
BASELINE ∆GHG YEAR 3				$\boldsymbol{Sim_{-1,\ N2O,CH4}}$

5.1.1 Transitioning from the Matched Baseline to the Blended Baseline

For most fields, it is unlikely that the project scenario crop will continue to match with the baseline comparison crop pattern for the entire crediting period. Thus, at some point it will likely be necessary for any project using the matched baseline to transition to the blended baseline. This can be a very straightforward activity.

The blended baseline relies on a separate, continuous modeling thread for every year of the historical baseline period, with the comparison crop pattern staggered so that each year is represented in each model run. These modeling threads begin at project initiation, so that in the year of the transition from the matched to the blended baseline, the project developer will simply adjust to averaging the GHG changes across all baseline modeling threads, rather than just those which correspond to the historical years with the matched crop.

5.2 Uncertainty Deduction

To conservatively estimate a project's actual emissions reduction, the number of credits is computed not from the "point estimate" of average emissions reduction (i.e., the average given the observed sample) but instead from the 30th percentile of the distribution of the estimated average emissions reduction. This distribution captures what other point estimates that would have been calculated had a different sample been collected (i.e., the "sampling distribution"). When a calibrated model is used to predict emissions reductions, the distribution also reflects point estimates that would have been calculated using a different sample of calibration data, as well as different model predictions that fall within the model's range of plausible errors (these sources of uncertainty are sometimes referred to as model variance). By calculating credits using the 30th percentile (also called a "one-sided confidence interval" or "exceedance probability" method), there is a 70% probability that the actual emissions reduction exceeds the amount claimed in the credits.

The 30th percentile should be calculated assuming that the average emissions reduction is normally distributed, i.e., the 30th percentile = $\widehat{ER_t} - \boldsymbol{z_{70\%}}\ \boldsymbol{s_{\widehat{ER_t}}}$ where $\boldsymbol{z_{70\%}}$ is the 70th percentile of a standard normal distribution. Equation 5.1 divides the distance between the estimated average and the 30th percentile ($\boldsymbol{z_{70\%}}\ \boldsymbol{s_{\widehat{ER_t}}}$) by $\widehat{ER_t}$ to compute a relative uncertainty deduction, UNC_t. In later calculations (e.g. see Equation 5.3 and Equation 5.6) estimated emission reductions are multiplied by $1 - UNC_t$ to scale emission reductions to the 30th percentile. (A relative deduction makes it easier to later distinguish between reversible and irreversible credits.) See Appendix D for detailed guidance on estimating the emissions reduction $\widehat{ER_t}$ and the associated uncertainty deduction UNC_t.

Equation 5.1. Uncertainty Deduction

$$\boldsymbol{UNC_t} = \frac{\boldsymbol{z_{70\%}}\ \mathbf{s}_{\widehat{\boldsymbol{ER_t}}}}{\widehat{\boldsymbol{ER_t}}}$$

Where,			<u>Units</u>
UNC_t	=	Total deduction for uncertainty for cultivation cycle *t*	
$s_{\widehat{ER_t}}$	=	Standard error of areal mean emission reduction $\left(\widehat{ER}\right)$	tCO_2e/acre
$\widehat{ER_t}$	=	Estimated per-acre average emissions reduction across all strata in cultivation cycle t	tCO_2e/acre
$\boldsymbol{z_{70\%}}$	=	z-score of the 70th percentile of a standard normal distribution ≈ 0.5244005127	

5.3 Reversible Emission Reductions

Reversible emission reductions for soil enrichment projects are those related to changes in SOC stocks (as shown in Figure 5.4). The contents of this section describe how reversible emission reductions are calculated for projects employing either tonne-tonne accounting (TTA) or tonne-year accounting (TYA), as described in Section 3.5, as well as how buffer pool contributions and reversals are quantified. Projects for which TTA applies must use Equation 5.2a, whereas those applying TYA must use Equation 5.2b. Under TYA, reversible emission reductions are quantified according to the length of time the CO_2e emissions are sequestered and/or contractually secured. Specifically, for each additional tonne of CO_2e that is stored and verified, reversible emission reductions are accounted for proportionally according to the amount of time for which it has or will be secured relative to the value of the atmospheric impact of maintaining each tonne in the ground for 100 years. This is achieved by multiplying the number of tonnes of additional sequestered CO_2e in a given Reporting Period by 1% per tonne for each year sequestered, based on the assumed time-value of the climate impact of reversible emission reductions, as described in Section 3.5.5. The commitment to secure CO_2e must be established through a PIA with the Reserve (see Section 3.5.3).

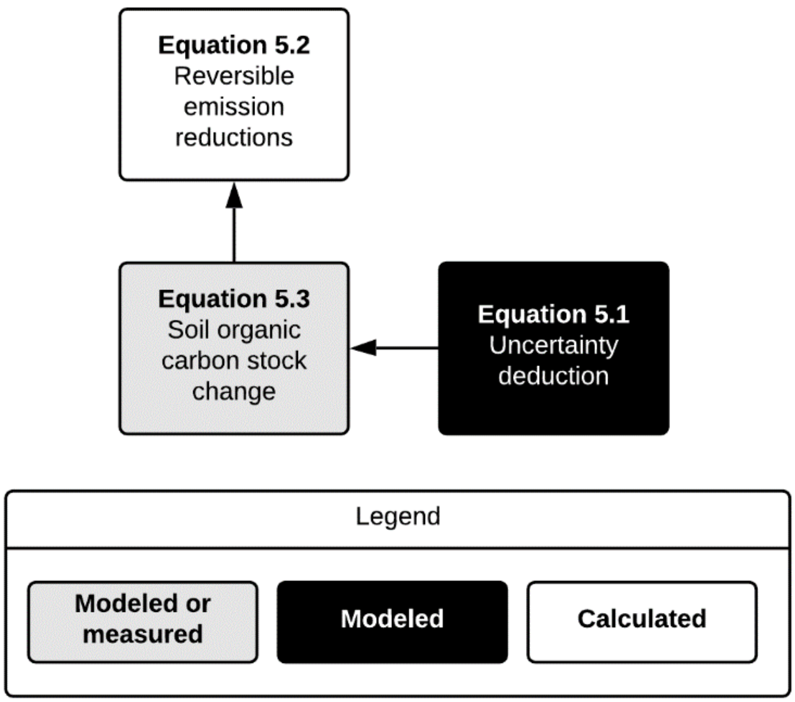

Figure 5.4. Map of Equations Related to the Quantification of Reversible Emission Reductions

Equation 5.2. Reversible GHG Emission Reductions

Equation 5.2a: If applying tonne-tonne accounting, then

$$\boldsymbol{ER_{Rev}} = \sum_{t} \Delta \boldsymbol{CO2\_soil_t} \times (\mathbf{1} - \boldsymbol{LE_t})$$

Equation 5.2b: If applying tonne-year accounting, then

$$\boldsymbol{ER_{Rev}} = \sum_{t} (\Delta \boldsymbol{CO2\_soil_t} \times (\boldsymbol{YR_t} + \boldsymbol{CL}) \times \mathbf{1\%} - \boldsymbol{PER_t}) \times (\mathbf{1} - \boldsymbol{LE_t})$$

Where,			Units
ER_{Rev}	=	Total reversible emission reductions for the reporting period	tCO_2e
$\Delta CO2\_soil_t$	=	Carbon dioxide emission reductions from soil organic carbon pool across all strata in cultivation cycle *t*	tCO_2e
YR_t	=	Length of time since the initiation of cultivation cycle *t* in which the additional carbon was sequestered, for each cultivation cycle in which additional carbon was sequestered	years
CL	=	Length of contractual agreement into future from current reporting period that secures all sequestered carbon	years
1%	=	Annual climate impact relative to 100-year permanence timeframe	%/year
PER_t	=	Previous credits issued for cultivation cycle *t*, for each cultivation cycle for which credits were issued	tCO_2e
LE_t	=	Leakage deduction during cultivation cycle *t*	

Box 5.2. Example of Tonne-Year Accounting

If the increase in SOC stocks was 100 tonnes of CO_2e in the first reporting period, and the Project Owner submits the project report at the end of a one-year first reporting period, and secures the 100 tonnes of CO_2e through a 20 year PIA, then 21 tCO_2e of reversible emission reductions will be recognized for crediting purposes. This is based on the 20 years for which the tonnes are secured through contract subsequent to the completion of the reporting period and the 1 year for which the tonnes have been already maintained through the first reporting period:

$$\boldsymbol{ER_{Rev}} = \sum(\mathbf{100} \times (\mathbf{1} + \mathbf{20}) \times \mathbf{1}\% - \mathbf{0})$$

Alternatively, if the first reporting period was 2 years, then 22 tCO_2e would be recognized following verification.

$$\boldsymbol{ER_{Rev}} = \sum(\mathbf{100} \times (\mathbf{2} + \mathbf{20}) \times \mathbf{1}\% - \mathbf{0})$$

In this first (one-year first reporting period) example, the project would have 79 tonnes-worth of emission reductions that have not yet been recognized for crediting purposes out of the initial 100 tonnes of CO_2e that were verified. If in the next year the PIA is maintained as is (i.e., term ends 20 years subsequent to the first reporting period), no additional credits will be issued for sequestration during the first reporting period since credits have already been issued in recognition of time-value that is eventually to be realized through the end of the existing PIA.

However, if in the next year the contract is extended by another year (so that the PIA still has a term of 20 years subsequent to the current reporting period), using the simplified 1% radiative forcing coefficient, another 1 tCO_2e would be converted into a CRT in addition to the prior credits because the project has secured the credits for another year toward the 100-year permanence requirement. PIAs may be extended in this way until the end of the contractual commitment reaches a date that is 100 years after the carbon was first sequestered. At that point, credits will have been issued for all of the 100 tonnes CO_2e sequestered in the first reporting period.

For each subsequent reporting period, a similar pattern is followed to calculate the amount of credits to be issued, accounting for the length of time after the reporting period end date covered by the remaining PIA term. If the PIA term ends prior to the end of the crediting period or a PIA was never implemented, a project will simply be issued credits at a rate of 1% of each reported and verified tonne, until 100% of each previously verified sequestered tonne has been issued. Thus, for a project with a 20-year PIA that sequesters an additional 100 t CO_2e each year and for which the PIA is not extended, crediting would be as follows:

Reporting Period (RP)	CRTs issued based on an additional 100 tCO_2e sequestered during each reporting period:										Total CRTs
	RP1	**RP2**	**RP3**	**…**	**RP20**	**RP21**	**RP22**	**RP23**	**…**	**RP30**	
1	21			…					…		**21**
2	0	20		…					…		**20**
3	0	0	19	…					…		**19**
…	…	…	…	…	…	…	…	…	…	…	**…**
20	0	0	0	…	2				…		**2**
21	0	0	0	…	0	1			…		**1**
22	1	1	1	…	1	1	1		…		**22**
23	1	1	1	…	1	1	1	1	…		**23**
…	…	…	…	…	…	…	…	…	…	…	**…**
30	1	1	1	…	1	1	1	1	…	1	**30**

Note: the reference here to 30 years assumes the project is able to make use of the potential two renewals to its 10-year crediting period, for a total potential 30 years of crediting per field (see Section 0 for guidance on crediting periods).

Although quantified as a reversible emission reduction, credits issued under TYA are no longer considered reversible once they have been maintained out of the atmosphere for the reporting period for which a given tonne-year is attributed. This is reflected in how reversals are calculated, as described in Section 3.5.2. For instance, in the first example above, the project is issued 1 credit for maintaining 100 tonnes of CO_2e out of the atmosphere for 1 year. The time-value of those 100 tonnes at that point in time is 1 year (i.e., 1% of the permanence requirement). Therefore, by issuing 1 credit, the time-value of that portion of the project's sequestration has been fully realized and is not reversible. Yet, the 20 other credits issued in this example were issued in advance of the time-value, as the time commitment for those credits has been secured by a PIA. Those credits are considered reversible as of the end of the first reporting period. If those stocks are maintained through the second reporting period, one of those 20 credits would be considered to be no longer reversible since the time-value of the 100 initially sequestered tonnes will have been realized for one more year (i.e., 2 total non-reversible credits). This continues accordingly until 100 years is reached (either through the passage of time or based on extending the PIA).

Determining the value to be used for the average carbon stocks in the SOC pool in the project scenario will differ depending on whether the stocks are modeled or directly measured for that reporting period. Where SOC stocks are directly measured, the Project Owner will demonstrate the sampling approach and the steps taken to determine average SOC stocks for each sample unit from the SOC sampling and analysis, as described in Section 6.5. Where SOC stocks are determined through the use of a model, the Project Owner must document the modeling approach used to estimate changes to average SOC stocks over time, as described in Section 6.6. In cases where the SOC stocks are modeled, this quantification will be a function of the input variables of that model (for simplicity, this is not illustrated in Equation 5.3)

Equation 5.3. Soil Organic Carbon Stock Change

$$\Delta \boldsymbol{CO2\_soil_t} = \sum_{\boldsymbol{s}} \left[\left(\overline{\Delta \boldsymbol{SOC_{s,t}}} - \overline{\Delta \boldsymbol{SOC_{bsl,s,t}}} \right) \times \boldsymbol{A_{s,t}} \right] \times (\boldsymbol{1} - \boldsymbol{UNC_t})$$

Where,			Units
$\Delta CO2\_soil_t$	=	Carbon dioxide emission reductions from soil organic carbon pool across all strata in cultivation cycle *t*	tCO_2e
$\overline{\Delta SOC_{s,t}}$	=	Average change in carbon stocks in the soil organic carbon pool in the project scenario for stratum *s* during cultivation cycle *t*	tCO_2e/acre
$\overline{\Delta SOC_{bsl,s,t}}$	=	Average change in carbon stocks in the soil organic carbon pool in the baseline scenario for stratum *s* during cultivation cycle *t*	tCO_2e/acre
$A_{s,t}$	=	Area of stratum *s* in cultivation cycle *t*	acres
UNC_t	=	Uncertainty in cultivation cycle *t* (Equation 5.1)	

5.3.1 Contribution to the Buffer Pool

For each reporting period for which the result from Equation 5.2 is positive, the Project Owner must transfer a quantity of credits (determined by Equation 5.4) to the Reserve Buffer Pool at the time of credit issuance. Credits that enter the buffer pool are held in trust for the benefit of all projects registered with the Reserve, to be used as compensation for unavoidable reversals, as described in Sections 3.5.2 and 5.3.2. Equation 5.4 shall be used to calculate the buffer pool contribution for the project during the reporting period.

At the time of development of this protocol the Reserve was not able to identify any risks of reversal for which the likelihood of occurrence should reasonably be deemed as high. Fires and catastrophic floods would not typically release the carbon that is stored underground. Volcanic activity is exceedingly rare in the conterminous U.S., and does not occur in the areas where crop cultivation typically occurs. 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. However, it was determined during the development of the protocol that the geographic concentration of fields in any given project, and indeed across the program as a whole, could exacerbate the GHG impacts of any catastrophic natural reversal event (i.e., If a flood was seen as a reversal risk, and a flood was to occur in a region where project field are concentrated, that could result in significant reversals for the given project). Thus, where more than 50% of a project's acreage is concentrated in a single LRR, the project must take a higher default deduction for unavoidable reversal risk, as set out Table 5.9 and Equation 5.4 below, of 0.075 and 0.05 respectively for geographically concentrated and dispersed projects. Projects that have less than 100 fields will not be required to contribute to the buffer pool at higher levels due to any geographic concentration. This exception is intended to ensure smaller projects are not unduly burdened by this requirement, recognizing that geographic distribution may be sufficient across the broader program.

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 is a private entity (e.g., an individual, corporation, NGO, etc.), an additional contribution is required to reflect risks from financial failure; the value of $Risk_{FF}$ shall be 0.1. An exception to these rules is made for cases where the Project Owner employs financial mechanisms like insurance or surety bonds, is a public agency or organization, has a contractual agreement identifying a successor entity in the event of the Project Owner's demise (including bankruptcy), in which case the value of $Risk_{FF}$ shall be 0.

For projects using tonne-year accounting, buffer pool contributions are based on the risk of reversals to emission reductions that have been secured via the PIA, if applicable. Credits issued to such projects based on the length of time any additional sequestered CO_2 has already been maintained are not considered reversible. Using the first example in Box 5.2, the 1 tonne of CO_2e credited based on the completion of the first reporting period is not reversible since that portion of the total amount of sequestered CO_2 represents the time-value of the reversible emission reduction that has already been realized, whereas the 20 tonnes of CO_2e credited based on the commitment of the Project Owner to maintaining sequestered stocks for 20 years under the PIA are reversible and would be the amount used to determine the buffer pool contributions for that reporting period.

Equation 5.4. Buffer Pool Contribution

$$Buffer_{rp} = Risk_{Rev,rp} \times ER_{Rev,rp}$$

Where,			Units
$Buffer_{rp}$	=	Total contribution to the buffer pool for reporting period *rp*	tCO_2e
$Risk_{Rev,rp}$	=	Cumulative risk of reversals for reporting period *rp*, from Table 5.9	tCO_2e
$ER_{Rev,rp}$	=	Total reversible emission reductions for the reporting period	tCO_2e

And,

$$Risk_{Rev,rp} = 1 - [(1 - Risk_{default}) \times (1 - Risk_{FF})]$$

Where,			Units
$Risk_{default}$	=	Default risk of unavoidable reversals, the value is either 0.05 or 0.075, as described in Table 5.9	%
$Risk_{FF}$	=	Additional risk related to financial failure, the value is either 0 or 0.1, as described in Table 5.9	%

Where the net change in carbon stocks is not a whole number, round the calculated CRT and buffer pool contribution down to the nearest whole number. Where the net change in carbon stocks is a whole number, round the calculated buffer pool contribution up, and the CRT volume down, to the nearest whole number.

As there are only two risk categories that contribute to $Risk_{rev,rp}$, each with two options, there are four possible values for this parameter. The potential project scenarios and the resulting value of $Risk_{rev,rp}$ are listed in Table 5.9.

Table 5.9. Possible Values of $Risk_{rev,rp}$

Geographically Dispersed (Y/N)	$Risk_{default}$	Project Owner Entity	Listed Financial Mechanisms	$Risk_{FF}$	$Risk_{rev,\ rp}$
Y	0.05	Private	Yes	0	**0.05**
Y	0.05	Public, private with successor entity, accredited land trust	n/a	0	**0.05**
N	0.075	Any	Yes	0	**0.075**
Y	0.05	Private	No	0.1	**0.145**
N	0.075	Private	No	0.1	**0.168**

Project Owners may be able to reduce the risk rating through actions that lower the risk profile of their project. If a project's risk rating declines, the Reserve may distribute previously withheld Buffer Pool CRTs to the Project Owner in proportion to the reduced risk, if the Reserve determines it is appropriate to do so. Similarly, however, the Reserve may require additional contributions to the Buffer Pool if the risk rating increases, to ensure that all CRTs (including those issued in prior years) are properly insured.

5.3.2 Reversals

If a reversal occurs during a reporting period (see Section 3.5), as indicated by a negative result from the application of Equation 5.2, the reversal must be compensated for with CRTs. Specific requirements depend on 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 based on quantified changes in soil carbon stocks across the entire project area and is irrespective of any emission reductions achieved via changes in CH_4 and N_2O. Although soil carbon may be lost on a portion of the project area as a result of changes in practices that release stored carbon stocks, such releases are considered within the context of the entire project area rather than in isolation. For example, if a single field were enrolled in a stand-alone project and the participating Field Manager undertook actions that represent a direct risk of reducing soil carbon levels relative to the baseline, then the risk of reversal on such fields should be examined closely. However, if that same field were enrolled in an aggregated project comprising many fields, the losses in carbon stocks from that single field would be considered in the full context of all project fields. If the combined increase in soil carbon stocks from other participating fields is greater than the reversals quantified from the subject field, those losses in soil carbon would not be considered a reversal and would simply be incorporated into the quantification of the project's total net change in soil carbon.

If the project area is subject to a net reversal, then the quantity of soil carbon reversed is considered to be equal to the total net loss of soil carbon across the project (if any), as quantified in Equation 5.2. The quantity of CRTs that must be retired to compensate for the amount of reversed soil carbon is determined using Equation 5.5, which recognizes the time-value of the CO_2 held out of the atmosphere and in sequestered soil carbon stocks prior to the time of the reversal, relative to the time remaining in the permanence time commitment for each area causing the reversal. As such, Equation 5.5 is not only applicable to all reversible emission reductions calculated using tonne-tonne accounting (Equation 5.2a), but also to those reversible emission reductions calculated using tonne-year accounting (Equation 5.2b) that are secured through the term of enforcement for the PIA since they are still considered reversible. Furthermore, Equation 5.5 is applicable during both the crediting period and the permanence period, though compensation for reversals occurring during the permanence period will be based on the difference between project and baseline soil carbon stocks for the area affected by the reversal, as reported in the final reporting period of the crediting period, as opposed to the measured and/or modeled difference in soil carbon reported during the crediting period.

Equation 5.5. Calculation of Compensation for Reversals

$$\boldsymbol{Rev} = \sum_{\boldsymbol{pc}}\left(\frac{\Delta \boldsymbol{CO2\_soil}_{\boldsymbol{rev,pc}}}{\sum \Delta \boldsymbol{CO2\_soil}_{\boldsymbol{rev,pc}}} \times \boldsymbol{ER}_{\boldsymbol{Rev}} \times \boldsymbol{Y}_{\boldsymbol{rp}} \times \boldsymbol{1}\%\right)$$

Where,			<u>Units</u>
Rev	=	Quantity of emission reductions affected by the reversal, summed for all cultivation cycles for which emission reductions have been credited in relation to the soil organic carbon pool	tCO_2e
$\Delta CO2\_soil_{rev,pc}$	=	Carbon dioxide emissions from soil organic carbon pool in the area of the project affected by the reversal (reported during the current reporting period) and with the same length of time remaining in the permanence commitment period *pc*	tCO_2e
ER_{Rev}	=	Net project reversal, as indicated by Equation 5.2	tCO_2e
Y_{rp}	=	Number of years remaining in the permanence time commitment for a given project area affected by the reversal at the time the reversal occurs	years
1%	=	Annual climate impact relative to 100-year permanence timeframe	%/year

Under this protocol, credits are considered reversed in the opposite order in which the credit was quantified and verified. For example, suppose a project was credited for 100 tonnes of reversible emission reductions in year 1 and another 50 tonnes in year 2. In year 3, a reversal occurs that releases 75 tonnes of emissions into the atmosphere (based on application of Equation 5.5). In this situation, the 50 credits issued in year 2 are considered reversed, along with 25 of the credits issued in year 1. Furthermore, for quantification purposes, a reversal is assumed to have occurred at the start of the reporting period during which it occurred, regardless when during the reporting period it actually occurred.

5.3.2.1 Compensating for 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. Alternatively, if the Reserve determines that an avoidable reversal has occurred, it shall deliver written notice to the Project Owner. 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(s) for which there has been a reversal.
2. Within a year of notifying the Reserve of a reversal, or receiving the avoidable reversal notice from the Reserve, the Project Owner must:
    a. provide the Reserve with a verified estimate of current SOC stocks. A site visit to the field(s) that are the cause of the reversal is not required, though verifiers may choose to visit such fields based on a field-level risk evaluation performed while selecting locations for site visits (see Section 8.4.1), and
    b. transfer to the Reserve a quantity of CRTs from its Reserve account equal to the size of any avoidable reversal as calculated in Equation 5.5, or, if the project expects to accumulate sufficient SOC changes in the following reporting period, the reversal may be carried forward to the next reporting period as “negative carryover” and applied as an adjustment to the volume of CRTs to be issued in the next reporting period.

3. The surrendered CRTs must be those that were issued to the soil enrichment project, or that were issued to other soil enrichment projects registered with the Reserve. If there is not a sufficient quantity of soil enrichment CRTs available for compensation, as determined by the Reserve, any other CRTs are acceptable.
4. The surrendered CRTs shall be retired or cancelled by the Reserve and designated in the Reserve software as compensating for an avoidable reversal.

5.3.2.2 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 5.5.
3. Within a year of notifying the Reserve of a reversal, or receiving the unavoidable reversal notice from the Reserve, the Project Owner must provide the Reserve with a verified estimate of current SOC stocks. A site visit to the field(s) that are the cause of the reversal is not required, though verifiers may choose to visit such fields based on a field-level risk evaluation performed while selecting locations for site visits (see Section 8.4.1).

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

5.4 Non-Reversible Emission Reductions

Non-reversible emission reductions for soil enrichment projects are those unrelated to changes in SOC stocks, such as reduced N_2O emission from fertilizer use or reduced CH_4 emissions from water management. Figure 5.5 illustrates the relationships between the equations used to quantify non-reversible emission reductions.

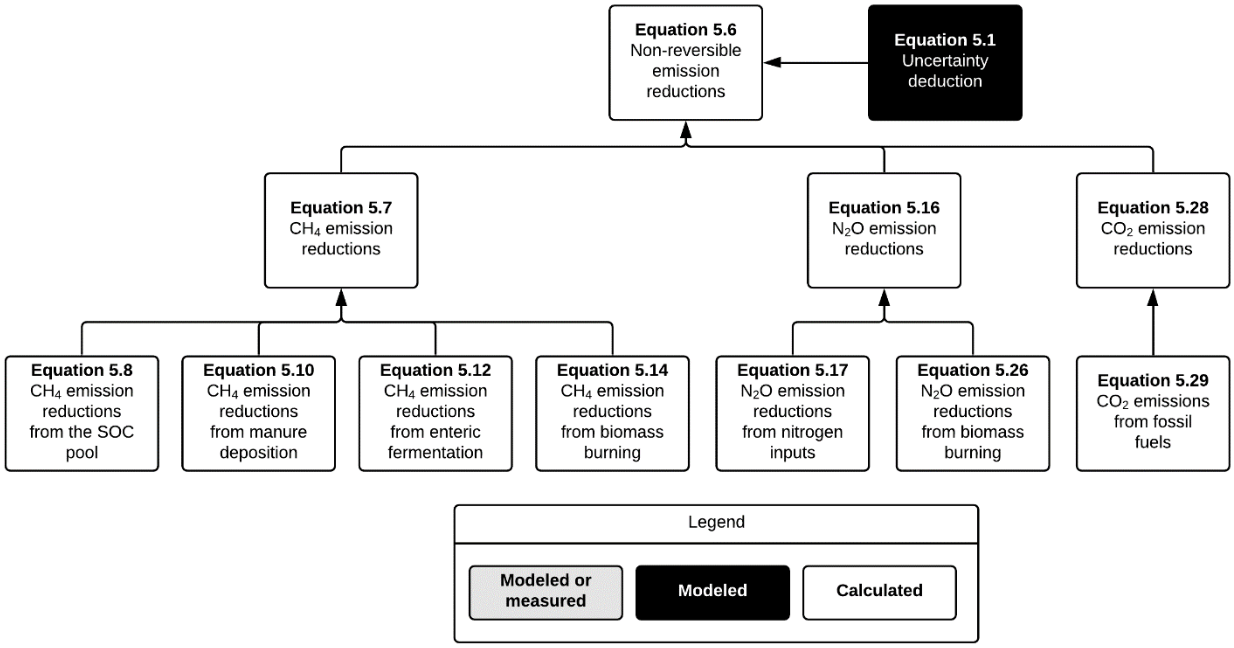

Figure 5.5. Map of Equations Related to the Quantification of Non-Reversible Emission Reductions

The sources and methods for quantification are the same in the baseline and project scenarios. The remaining equations in this section can be applied in either scenario. Thus, they are not presented here twice. Rather, project developers should add subscripts as needed to denote whether the parameters and results are relevant to the baseline scenario (“bsl”) or the project scenario (“pr”). Emission reductions are calculated for each source, with specific equations denoting the point at which baseline and project emissions are compared.

Equation 5.6. Non-Reversible Emission Reductions

$$\boldsymbol{ER_{NonRev}} = \sum_{s,t}\left[\left(\overline{\Delta \boldsymbol{CH4}_{s,t}} + \overline{\Delta \boldsymbol{N2O}_{s,t}} + \overline{\Delta \boldsymbol{CO2\_NR}_{s,t}}\right) \times \boldsymbol{A_{s,t}} \times (\boldsymbol{1} - \boldsymbol{LE_t})\right] \times (\boldsymbol{1} - \boldsymbol{UNC_t})$$

Where,

			Units
ER_{NonRev}	=	Total non-reversible emission reductions for the reporting period	tCO_2e
$\overline{\Delta CH4_{s,t}}$	=	Average methane emission reductions in stratum *s* during cultivation cycle *t* (Equation 5.7)	tCO_2e/acre
$\overline{\Delta N2O_{s,t}}$	=	Average nitrous oxide emission reductions in stratum *s* during cultivation cycle *t* (Equation 5.16)	tCO_2e/acre
$\overline{\Delta CO2\_NR_{s,t}}$	=	Average carbon dioxide emission reductions from fossil fuel use in stratum *s* during cultivation cycle *t* (Equation 5.28)	tCO_2e/acre
LE_t	=	Leakage deduction during cultivation cycle *t*	ratio
$A_{s,t}$	=	Area of stratum *s* in cultivation cycle *t*	acres
UNC_t	=	Uncertainty deduction for cultivation cycle *t* (Equation 5.1)	

5.4.1 Methane Emissions

Sources of methane emissions in a soil enrichment project include methanogenesis in the soil (Equation 5.9), manure deposited by grazing animals (Equation 5.10), enteric fermentation in grazing animals (Equation 5.12), and biomass burning (Equation 5.14)**Error! Reference source not found.** and . Figure 5.6 illustrates the relationships between the equations used to quantify methane emission reductions.

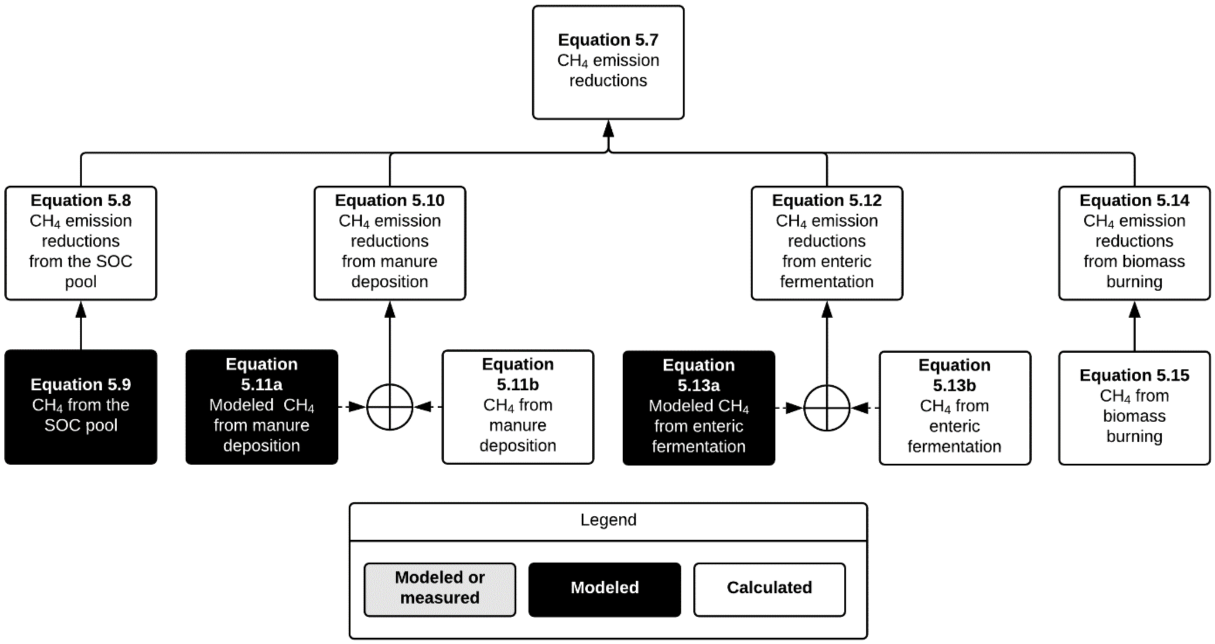

Figure 5.6. Map of Equations Related to the Quantification of Methane Emission Reductions

Equation 5.7. Methane Emission Reductions

$$\overline{\Delta \boldsymbol{CH4}_{s,t}} = \overline{\Delta \boldsymbol{CH4\_soil}_{s,t}} + \overline{\Delta \boldsymbol{CH4\_md}_{s,t}} + \overline{\Delta \boldsymbol{CH4\_ent}_{s,t}} + \overline{\Delta \boldsymbol{CH4\_bb}_{s,t}}$$

Where,			<u>Units</u>
$\overline{\Delta CH4_{s,t}}$	=	Average methane emission reductions in stratum *s* during cultivation cycle *t*	tCO_2e/acre
$\overline{\Delta CH4\_soil_{s,t}}$	=	Average methane emission reductions from the soil organic carbon pool in stratum *s* during cultivation cycle *t* (Equation 5.8)	tCO_2e/acre
$\overline{\Delta CH4\_md_{s,t}}$	=	Average methane emission reductions from manure deposition in stratum *s* during cultivation cycle *t* (Equation 5.10)	tCO_2e/acre
$\overline{\Delta CH4\_ent_{s,t}}$	=	Average methane emission reductions from enteric fermentation in stratum *s* during cultivation cycle *t* (Equation 5.12)	tCO_2e/acre
$\overline{\Delta CH4\_bb_{s,t}}$	=	Average methane emission reductions from biomass burning in stratum *s* during cultivation cycle *t* (Equation 5.14)	tCO_2e/acre

Depending upon nutrient inputs and weather conditions, methanogenic bacteria in the soil will convert some amount of organic matter into CH_4. This activity is affected by agricultural management practices and may be estimated through the use of a model, as shown in Equation 5.9.

Equation 5.8. Methane Emission Reductions from the Soil Organic Carbon Pool

$$\overline{\Delta \boldsymbol{CH4\_soil}_{s,t}} = \overline{\boldsymbol{CH4\_soil}_{bsl,s,t}} - \overline{\boldsymbol{CH4\_soil}_{pr,s,t}}$$

Where,			Units
$\overline{\Delta CH4\_soil_{s,t}}$	=	Average methane emission reductions from the soil organic carbon pool in stratum *s* during cultivation cycle *t*	tCO_2e/acre
$\overline{CH4\_soil_{bsl,s,t}}$	=	Average baseline methane emissions from the soil organic carbon pool in stratum *s* during cultivation cycle *t* (Equation 5.9)	tCO_2e/acre
$\overline{CH4\_soil_{pr,s,t}}$	=	Average project methane emissions from the soil organic carbon pool in stratum *s* during cultivation cycle *t* (Equation 5.9)	tCO_2e/acre

Equation 5.9. Methane Emissions from the Soil Organic Carbon Pool

$$\overline{\boldsymbol{CH4\_soil}_{s,t}} = f_{\boldsymbol{CH_4SOC}}(\boldsymbol{Var\ A}_{s,t}, \boldsymbol{Var\ B}_{s,t}, \dots) \times \boldsymbol{GWP}_{CH_4}$$

Where,			Units
$\overline{CH4\_soil_{s,t}}$	=	Average methane emissions from the soil organic carbon pool in stratum *s* during cultivation cycle *t*	tCO_2e/acre
f_{CH4SOC}	=	Model predicting methane emissions from the soil organic carbon pool	tCH_4/acre
$Var\ A_{s,t}$	=	Value of model input variable A in the baseline scenario for stratum *s* in cultivation cycle *t*	
$Var\ B_{s,t}$	=	Value of model input variable B in the baseline scenario for stratum *s* in cultivation cycle *t*	
GWP_{CH4}	=	Global warming potential for CH_4 (Table 5.1)	tCO_2e/tCH_4

Where livestock graze in the project area, they will deposit manure on the soil. This may occur in the baseline scenario, project scenario, or both. Equation 5.10 quantifies the CH_4 emissions from this manure deposition, caused by anaerobic bacteria. This source of CH_4 may be quantified either with a model (Equation 5.11a) or using default values and project data (Equation 5.11b).

Equation 5.10. Methane Emission Reductions from Manure Deposition

$$\overline{\Delta \boldsymbol{CH4\_md}_{s,t}} = \overline{\boldsymbol{CH4\_md}_{bsl,s,t}} - \overline{\boldsymbol{CH4\_md}_{pr,s,t}}$$

Where,

			Units
$\overline{\Delta CH4\_md_{s,t}}$	=	Average methane emission reductions from manure deposition in stratum *s* during cultivation cycle *t*	tCO_2e/acre
$\overline{CH4\_md_{bsl,s,t}}$	=	Average baseline methane emissions from manure deposition in stratum *s* during cultivation cycle *t* (Equation 5.11)	tCO_2e/acre
$\overline{CH4\_md_{pr,s,t}}$	=	Average project methane emissions from manure deposition in stratum *s* during cultivation cycle *t* (Equation 5.11)	tCO_2e/acre

Equation 5.11. Methane Emissions from Manure Deposition

Equation 5.11a: Modeled methane emissions from manure deposition

$$\overline{\boldsymbol{CH4\_md_{s,t}}} = \mathfrak{f}_{\boldsymbol{CH_4md}}(\boldsymbol{Var\ A_{s,t}}, \boldsymbol{Var\ B_{s,t}}, \dots) \times \boldsymbol{GWP_{CH_4}}$$

Where,			Units
$\overline{CH4\_md_{s,t}}$	=	Average methane emissions from manure deposition in stratum *s* during cultivation cycle *t*	tCO_2e/acre
$\mathfrak{f}_{CH4md}$	=	Model predicted methane emissions from manure deposition	tCH_4/acre
Var $A_{s,t}$	=	Value of model input variable A in the baseline scenario for stratum *s* in cultivation cycle *t*	
Var $B_{s,t}$	=	Value of model input variable B in the baseline scenario for stratum *s* in cultivation cycle *t*	
GWP_{CH4}	=	Global warming potential for CH_4 (Table 5.1)	tCO_2e/tCH_4

Equation 5.11b: Calculated methane emissions from manure deposition

$$\overline{\boldsymbol{CH4\_md_{s,t}}} = \sum_{\boldsymbol{l}} \left(\boldsymbol{AGD_{l,s,t}} \times \boldsymbol{VS_l} \times \boldsymbol{B_{0,l}} \right) \times \frac{\boldsymbol{MCF_{PRP}} \times \boldsymbol{\rho_{CH_4}} \times \boldsymbol{GWP_{CH_4}}}{\boldsymbol{1000}} \times \frac{\boldsymbol{1}}{\boldsymbol{A_s}}$$

Where,			Units
$\overline{CH4\_md_{s,t}}$	=	Average methane emissions from manure deposition in stratum *s* during cultivation cycle *t*	tCO_2e/acre
$AGD_{l,s,t}$	=	Animal grazing days for livestock category *l*, in stratum *s*, during cultivation cycle *t* (see Box 5.3). Per Section 5.5.1, the minimum value allowed for the project scenario is equal to the average value from the historical baseline period	animal days
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
1000	=	Conversion factor	kg/t
GWP_{CH4}	=	Global warming potential for CH_4 (Table 5.1)	tCO_2e/tCH_4
A_s	=	Area of stratum *s*	acres

Box 5.3. Determining Animal Grazing Days (AGD_l)

Equation 5.11, Equation 5.13, Equation 5.23, and Equation 5.24 require 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.

Where ruminant livestock graze in the project area, they will also generate CH_4 through enteric fermentation. This may occur in the baseline scenario, project scenario, or both. Equation 5.12 quantifies the CH_4 emissions from this enteric fermentation, caused by anaerobic gut bacteria. This source of CH_4 may be quantified either with a model (Equation 5.13a) or using default values and project data (Equation 5.13b).

Equation 5.12. Methane Emission Reductions from Enteric Fermentation

$$\overline{\Delta CH4\_ent_{s,t}} = \overline{CH4\_ent_{bsl,s,t}} - \overline{CH4\_ent_{pr,s,t}}$$

Where,

			Units
$\overline{\Delta CH4\_ent_{s,t}}$	=	Average methane emission reductions from enteric fermentation in stratum *s* during cultivation cycle *t*	tCO_2e/acre
$\overline{CH4\_ent_{bsl,s,t}}$	=	Average baseline methane emissions from enteric fermentation in stratum *s* during cultivation cycle *t* (Equation 5.13)	tCO_2e/acre
$\overline{CH4\_ent_{pr,s,t}}$	=	Average project methane emissions from enteric fermentation in stratum *s* during cultivation cycle *t* (Equation 5.13)	tCO_2e/acre

Equation 5.13. Methane Emissions from Enteric Fermentation

Equation 5.13a: Modeled methane emissions from enteric fermentation

$$\overline{\boldsymbol{CH4\_ent}_{s,t}} = \mathfrak{f}_{CH_4ent}(\boldsymbol{Var\ A}_{s,t}, \boldsymbol{Var\ B}_{s,t}, \ldots) \times \boldsymbol{GWP}_{CH_4}$$

Where,			Units
$\overline{CH4\_ent_{s,t}}$	=	Average methane emissions from enteric fermentation in stratum *s* during cultivation cycle *t*	tCO_2e/acre
$\mathfrak{f}_{CH4md}$	=	Model predicting methane emissions from enteric fermentation	tCH_4/acre
$Var\ A_{s,t}$	=	Value of model input variable A in the baseline scenario for stratum *s* in cultivation cycle *t*	
$Var\ B_{s,t}$	=	Value of model input variable B in the baseline scenario for stratum *s* in cultivation cycle *t*	
GWP_{CH4}	=	Global warming potential for CH_4 (Table 5.1)	tCO_2e/tCH_4

Equation 5.13b: Calculated methane emissions from enteric fermentation

$$\overline{\boldsymbol{CH4\_ent}_{s,t}} = \sum_{l}(\boldsymbol{AGD}_{l,s,t} \times \boldsymbol{PEF}_{ent,l}) \times \frac{\mathbf{1}}{\boldsymbol{A}_s} \times \frac{\boldsymbol{GWP}_{CH_4}}{\mathbf{1000}}$$

Where,			Units
$\overline{CH4\_ent_{s,t}}$	=	Average methane emissions from enteric fermentation in stratum *s* during cultivation cycle *t*	tCO_2e/acre
$AGD_{l,s,t}$	=	Animal grazing days for livestock category *l*, in stratum *s*, during cultivation cycle *t* (see Box 5.3). Per Section 5.5.1, the minimum value allowed for the project scenario is equal to the average value from the historical baseline period	animal days
$PEF_{ent,l}$	=	Project emission factor for enteric methane emissions from livestock category *l* in the project state[20]	kg CH_4/head/day
A_s	=	Area of stratum *s*	acres
1000	=	Conversion factor	kg/t
GWP_{CH4}	=	Global warming potential for CH_4 (Table 5.1)	tCO_2e/tCH_4

Where there is fire on the project area, either in the baseline or project scenario, some portion of the organic matter will be converted to CH_4 as a byproduct of the combustion process. Equation 5.14 and Equation 5.15 quantify this gas and source using default emission factors combined with an estimate of the mass of aboveground dry matter in the area affected by fire. Emission reductions associated with reductions in the use of fire to manage crop residues can be credited, commensurate with any yield changes, as long as the emissions associated with the alternative management of such stubble have been accounted for (this may include via livestock grazing of such residues, or the incorporation of residual biomass into the soil etc.). Projects seeking credit for reduced biomass burning must demonstrate to their verifier how the alternative management of such biomass has been accounted for.

[20] Default emission factors and parameters can be found in a separate document, *SEP Parameters*, available at: http://www.climateactionreserve.org/how/protocols/soil-enrichment/.

Equation 5.14. Methane Emission Reductions from Biomass Burning

$$\overline{\Delta CH4\_bb_{s,t}} = \overline{CH4\_bb_{bsl,s,t}} - \overline{CH4\_bb_{pr,s,t}}$$

Where,

			Units
$\overline{\Delta CH4\_bb_{s,t}}$	=	Average methane emission reductions from biomass burning in stratum *s* during cultivation cycle *t*	tCO_2e/acre
$\overline{CH4\_bb_{bsl,s,t}}$	=	Average baseline methane emissions from biomass burning in stratum *s* during cultivation cycle *t* (Equation 5.15)	tCO_2e/acre
$\overline{CH4\_bb_{pr,s,t}}$	=	Average project methane emissions from biomass burning in stratum *s* during cultivation cycle *t* (Equation 5.15)	tCO_2e/acre

Equation 5.15. Methane Emissions from Biomass Burning

$$\overline{CH4\_bb_{s,t}} = \frac{\sum_{c=1}^{C} MB_{c,s,t} \times CF_c \times EF_{c,CH_4}}{A_s} \times \frac{1}{10^6} \times GWP_{CH_4}$$

Where,

			Units
$\overline{CH4\_bb_{s,t}}$	=	Average methane emissions from biomass burning in stratum *s* during cultivation cycle *t*	tCO_2e/acre
$MB_{c,s,t}$	=	Mass of agricultural residues of type *c* burned in stratum *s* in cultivation cycle *t*	kg
CF_c	=	Combustion factor for agricultural residue type *c*, based on proportion of pre-fire fuel biomass consumed	
$EF_{c,CH4}$	=	Methane emission factor for the burning of agricultural residue type *c*	gCH_4/kg dry matter burnt
A_s	=	Area of stratum *s*	acres
$1/10^6$	=	Conversion factor	g/t
GWP_{CH4}	=	Global warming potential for CH_4 (Table 5.1)	tCO_2e/tCH_4

5.4.2 Nitrous Oxide Emissions

Sources of nitrous oxide emissions in a soil enrichment project include fertilizer use (Equation 5.19), manure deposited by grazing animals (Equation 5.22), use of N-fixing species (Equation 5.25), and biomass burning (Equation 5.26). Figure 5.7 illustrates the relationships between the equations used to quantify N_2O emission reductions. In certain regions, it is possible a water source used for irrigation may contribute a material amount of nitrogen to the crop system. Where projects are aware of significant nitrogen levels in irrigation water sources, the amount of nitrogen applied via irrigation should be quantified. Projects that are aware of such information are required to provide details to their verifiers, and verifiers will consider if inclusion / exclusion is appropriate in the circumstances (i.e., if the N_2O emissions related to levels of nitrogen from the irrigation water source are *de minimis* they may reasonably be excluded). Project developers are not required to proactively confirm, and verifiers are not required to proactively verify, whether every irrigation source contributes material amounts of nitrogen that should be included here. The Reserve will independently identify regions of concern and advise project developers and verifiers accordingly.

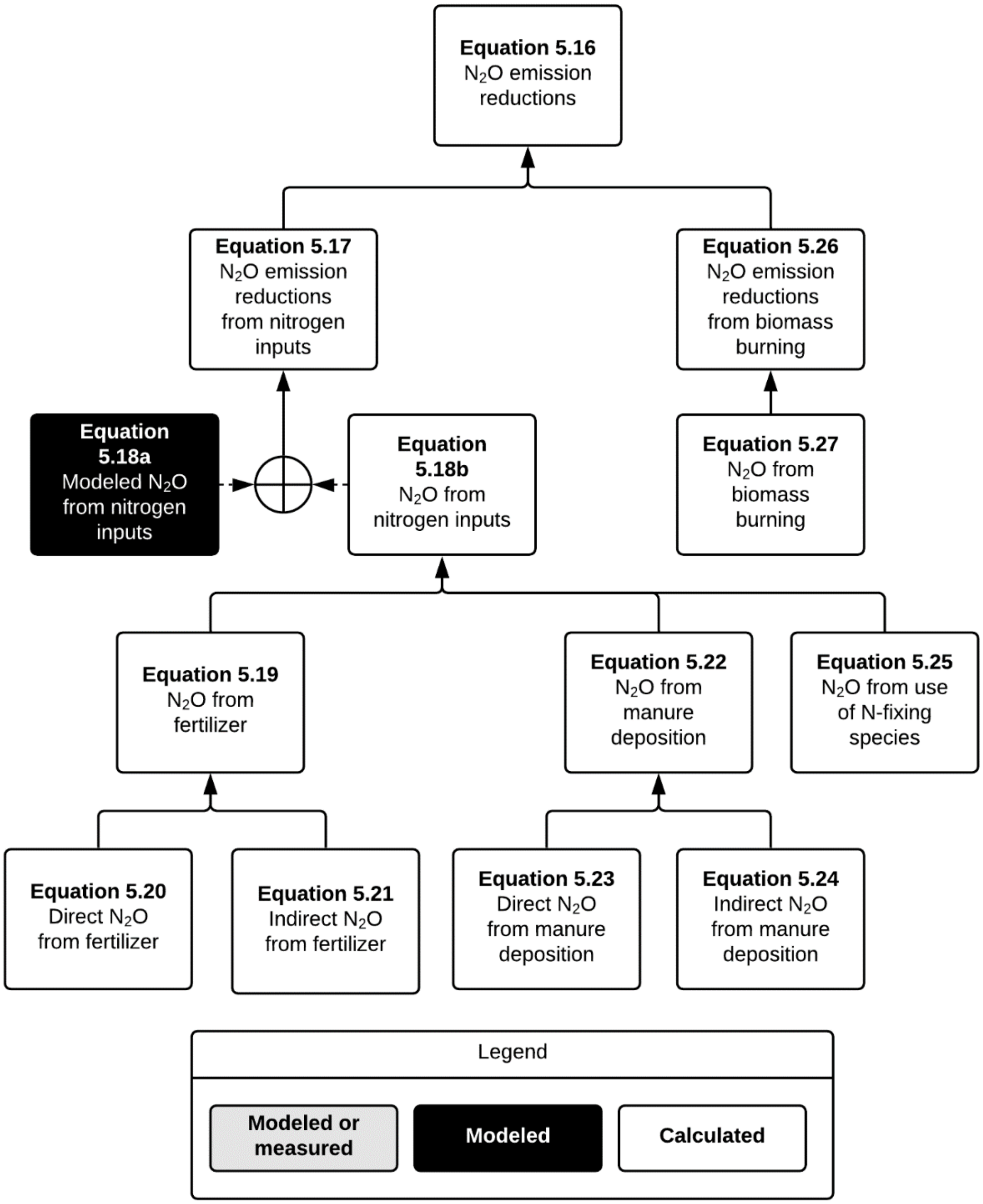

Figure 5.7. Map of Equations Related to the Quantification of Nitrous Oxide Emission Reductions

Equation 5.16. Nitrous Oxide Emission Reductions

$$\overline{\Delta \boldsymbol{N2O}_{s,t}} = \overline{\Delta \boldsymbol{N2O\_input}_{s,t}} + \overline{\Delta \boldsymbol{N2O\_bb}_{s,t}}$$

Where,			Units
$\overline{\Delta N2O_{s,t}}$	=	Average nitrous oxide emission reductions in stratum *s* in cultivation cycle *t*	tCO_2e/acre
$\overline{\Delta N2O\_input_{s,t}}$	=	Average nitrous oxide emission reductions due to nitrogen inputs to soils in stratum *s* in cultivation cycle *t* (Equation 5.17)	tCO_2e/acre
$\overline{\Delta N2O\_bb_{s,t}}$	=	Average nitrous oxide emission reductions due to biomass burning in stratum *s* in cultivation cycle *t* (Equation 5.28)	tCO_2e/acre

Equation 5.17. Nitrous Oxide Emission Reductions from Nitrogen Inputs

$$\overline{\Delta \boldsymbol{N2O\_input}_{s,t}} = \overline{\boldsymbol{N2O\_input}_{bsl,s,t}} - \overline{\boldsymbol{N2O\_input}_{pr,s,t}}$$

Where,			Units
$\overline{\Delta N2O\_input_{s,t}}$	=	Average nitrous oxide emission reductions due to nitrogen inputs to soils in stratum *s* in cultivation cycle *t*	tCO_2e/acre
$\overline{N2O\_input_{bsl,s,t}}$	=	Average baseline nitrous oxide emissions due to nitrogen inputs to soils in stratum *s* in cultivation cycle *t* (Equation 5.18)	tCO_2e/acre
$\overline{N2O\_input_{pr,s,t}}$	=	Average project nitrous oxide emissions due to nitrogen inputs to soils in stratum *s* in cultivation cycle *t* (Equation 5.18)	tCO_2e/acre

N_2O emissions from nitrogen inputs on the project area are quantified for both the baseline and project scenarios using Equation 5.18. These emissions may be quantified using a model (Equation 5.18a) or through default values and project data (Equation 5.18b).

Equation 5.18. Nitrous Oxide Emissions from Nitrogen Inputs

Equation 5.18a: Modeled nitrous oxide emissions from nitrogen inputs

$$\overline{\boldsymbol{N2O\_input_{s,t}}} = \mathfrak{f}_{N_2Oinput}(\boldsymbol{Var\ A_{s,t}}, \boldsymbol{Var\ B_{s,t}}, \dots) \times \boldsymbol{GWP_{N_2O}}$$

Where,			Units
$\overline{N2O\_input_{s,t}}$	=	Average nitrous oxide emissions due to nitrogen inputs to soils in stratum *s* in cultivation cycle *t*	tCO_2e/acre
$\mathfrak{f}_{N2Oinput}$	=	Model predicting nitrous oxide emissions from nitrogen inputs	tN_2O/acre
Var $A_{s,t}$	=	Value of model input variable A in stratum *s* in cultivation cycle *t*	
Var $B_{s,t}$	=	Value of model input variable B in stratum *s* in cultivation cycle *t*	
GWP_{N2O}	=	Global warming potential for N_2O (Table 5.1)	tCO_2e/tN_2O

Equation 5.18b: Calculated nitrous oxide emissions from nitrogen inputs

$$\overline{\boldsymbol{N2O\_input_{s,t}}} = \frac{\boldsymbol{N2O\_fert_{s,t}} + \boldsymbol{N2O\_md_{s,t}} + \boldsymbol{N2O\_Nfix_{s,t}}}{\boldsymbol{A_s}}$$

Where,			Units
$\overline{N2O\_input_{s,t}}$	=	Average nitrous oxide emissions due to nitrogen inputs to soils in stratum *s* in cultivation cycle *t*	tCO_2e
$N2O\_fert_{s,t}$	=	Nitrous oxide emissions due to fertilizer use in stratum *s* in cultivation cycle *t*	tCO_2e
$N2O\_md_{s,t}$	=	Nitrous oxide emissions due to manure deposition in stratum *s* in cultivation cycle *t*	tCO_2e
$N2O\_Nfix_{s,t}$	=	Nitrous oxide emissions from all crop residues (including those from N-fixing species) in stratum *s* in cultivation cycle *t*	tCO_2e
A_s	=	Area of stratum *s*	acres

Application of organic or synthetic fertilizers to the project area will result in both direct and indirect emissions of N_2O (Equation 5.19).

Equation 5.19. Nitrous Oxide Emissions from Fertilizer

$$\boldsymbol{N2O\_fert_{s,t}} = \boldsymbol{N2O\_fert_{direct,s,t}} + \boldsymbol{N2O\_fert_{indirect,s,t}}$$

Where,			Units
$N2O\_fert_{s,t}$	=	Nitrous oxide emissions due to fertilizer use in stratum *s* n cultivation cycle *t*	tCO_2e
$N2O\_fert_{direct,s,t}$	=	Direct nitrous oxide emissions due to fertilizer use in stratum *s* in cultivation cycle *t* (Equation 5.20)	tCO_2e
$N2O\_fert_{indirect,s,t}$	=	Indirect nitrous oxide emissions due to fertilizer use in stratum *s* in cultivation cycle *t* (Equation 5.21)	tCO_2e

Direct N_2O emissions from fertilizer application are quantified according to Equation 5.20.

Equation 5.20. Direct Nitrous Oxide Emissions from Fertilizer

$$\boldsymbol{N2O\_fert_{direct,s,t} = \left(M_{SF,s,t} \times NC_{SF} + M_{OF,s,t} \times NC_{OF}\right) \times EF_{Ndirect} \times \frac{44}{28} \times GWP_{N_2O} \times EF_{NUE}}$$

Where,			Units
$N2O\_fert_{direct,s,t}$	=	Direct nitrous oxide emissions due to fertilizer use in stratum *s* in cultivation cycle *t*	tCO_2e
$M_{SF,s,t}$	=	Mass of N containing synthetic fertilizer applied for stratum *s* in cultivation cycle *t*	t
NC_{SF}	=	N content of baseline synthetic fertilizer applied	tN/t fertilizer
$M_{OF,s,t}$	=	Mass of N containing organic fertilizer applied for stratum *s* in cultivation cycle *t*	t
NC_{OF}	=	N content of baseline organic fertilizer applied	tN/t fertilizer
$EF_{Ndirect}$	=	Emission factor for nitrous oxide emissions from N additions from synthetic fertilizers, organic amendments and crop residues	tN_2O / tN applied
44/28	=	Molar mass ratio of N_2O to N	kg N_2O/kg N_2O-N
GWP_{N2O}	=	Global warming potential for N_2O (Table 5.1)	tCO_2e/tN_2O

Indirect N_2O emissions from fertilizer application (due to leaching, volatilization, and run-off) are quantified according to Equation 5.21.

Equation 5.21. Indirect Nitrous Oxide Emissions from Fertilizer

$$\boldsymbol{N2O\_fert_{indirect,s,t} = \left[\left(M_{SF,s,t} \times NC_{SF} \times Frac_{GASF} + M_{OF,s,t} \times NC_{OF} \times Frac_{GASM}\right) \times EF_{Nvolat} + \left(M_{SF,s,t} \times NC_{SF} + M_{OF,s,t} \times NC_{OF}\right) \times Frac_{LEACH} \times EF_{Nleach}\right] \times \frac{44}{28} \times GWP_{N_2O}}$$

Where,			Units
$N2O\_fert_{indirect,s,t}$	=	Indirect nitrous oxide emissions due to fertilizer use in stratum *s* in cultivation cycle *t*	tCO_2e/
$M_{SF,s,t}$	=	Mass of N containing synthetic fertilizer applied for stratum *s* in cultivation cycle *t*	t
NC_{SF}	=	N content of baseline synthetic fertilizer applied	tN/t fertilizer
$Frac_{GASF}$	=	Fraction of all synthetic N added to soils that volatilizes as NH_3 and NO_x	
$M_{OF,s,t}$	=	Mass of N containing organic fertilizer applied for stratum *s* in cultivation cycle *t*	t
NC_{OF}	=	N content of baseline organic fertilizer applied	tN/t fertilizer
$Frac_{GASM}$	=	Fraction of all organic N added to soils that volatilizes as NH_3 and NO_x	
EF_{Nvolat}	=	Emission factor for nitrous oxide emissions from atmospheric deposition of N on soils and water surfaces	tN_2O-N / (tNH_3-N + NO_x-N volatilized)
$Frac_{LEACH}$	=	Fraction of N added (synthetic or organic) to soils that is lost through leaching and runoff, in regions where leaching and runoff occurs. Equal to 0 where average annual precipitation is less than potential evapotranspiration, except where irrigation is employed	tN_2O-N / tN leached and runoff
EF_{Nleach}	=	Emission factor for nitrous oxide emissions from leaching and runoff	
44/28	=	Molar mass ratio of N_2O to N	kg N_2O/kg N_2O-N
GWP_{N2O}	=	Global warming potential for N_2O (Table 5.1)	tCO_2e/tN_2O

Equation 5.22. Nitrous Oxide Emissions from Manure Deposition

$$\boldsymbol{N2O\_md_{s,t} = N2O\_md_{direct,s,t} + N2O\_md_{indirect,s,t}}$$

Where,			Units
$N2O\_md_{s,t}$	=	Nitrous oxide emissions due to manure deposition in stratum *s* in cultivation cycle *t*	tCO_2e~~/~~
$N2O\_md_{direct,s,t}$	=	Direct nitrous oxide emissions due to manure deposition in stratum *s* in cultivation cycle *t* (Equation 5.23)	tCO_2e~~/~~
$N2O\_md_{indirect,s,t}$	=	Indirect nitrous oxide emissions due to manure deposition in stratum *s* in cultivation cycle *t* (Equation 5.24)	tCO_2~~e/~~

Equation 5.23. Direct Nitrous Oxide Emissions from Manure Deposition

$$N2O\_md_{direct,s,t} = \sum_{l} \left(AGD_{l,s,t} \times Nex_l \times EF_{N_2O,md,l} \right) \times \frac{44}{28} \times \frac{GWP_{N_2O}}{1000}$$

Where,			Units
$N2O\_md_{direct,s,t}$	=	Direct nitrous oxide emissions due to manure deposition in stratum *s* in cultivation cycle *t*	tCO_2e
$AGD_{l,s,t}$	=	Animal grazing days for livestock category *l*, in stratum *s*, during cultivation cycle *t* (see Box 5.3). Per Section 5.5.1, the minimum value allowed for the project scenario is equal to the average value from the historical baseline period	animal days
Nex_l	=	Nitrogen excreted by grazing animals in livestock category *l*	kg N/head/day
$EF_{N2O,md,l}$	=	Emission factor for nitrous oxide from manure and urine deposited on soils by livestock type *l*	kg N_2O-N/kg N input
44/28	=	Molar mass ratio of N_2O to N	kg N_2O/kg N_2O-N
GWP_{N2O}	=	Global warming potential for N_2O (Table 5.1)	tCO_2e/tN_2O
1000	=	Conversion factor	kg/t

Equation 5.24. Indirect Nitrous Oxide Emissions from Manure Deposition

$$N2O\_md_{indirect,s,t} = \sum_{l} \left[\left(AGD_{l,s,t} \times Nex_l \times Frac_{GASMD} \right) \times EF_{Nvolat} + \left(AGD_{l,s,t} \times Nex_l \right) \times Frac_{LEACHMD} \times EF_{Nleach} \right] \times \frac{44}{28} \times GWP_{N2O}$$

Where,			Units
$N2O\_md_{indirect,s,t}$	=	Indirect nitrous oxide emissions due to manure deposition in stratum *s* in cultivation cycle *t*	tCO_2e
$AGD_{l,s,t}$	=	Animal grazing days for livestock category *l*, in stratum *s*, during cultivation cycle *t* (see Box 5.3). Per Section 5.5.1, the minimum value allowed for the project scenario is equal to the average value from the historical baseline period	animal days
Nex_l	=	Nitrogen excreted by grazing animals in livestock category *l*	kg N/head/day
$Frac_{GASMD}$	=	Fraction of manure N added to soils that volatilizes as NH_3 and NO_x	tNH_3–N + NO_x–N) / tN applied or deposited
EF_{Nvolat}	=	Emission factor for nitrous oxide emissions from atmospheric deposition of N on soils and water surfaces	tN_2O-N /(tNH_3-N + NO_x-N volatilized)
$Frac_{LEACHMD}$	=	Fraction of manure N added to soils that is lost through leaching and runoff, in regions where leaching and runoff occurs. Equal to 0 where average annual precipitation is less than potential evapotranspiration, unless irrigation is employed.	tN / tN additions or deposition by grazing animals
EF_{Nleach}	=	Emission factor for nitrous oxide emissions from leaching and runoff	tN_2O-N / tN leached and runoff
44/28	=	Molar mass ratio of N_2O to N	kg N_2O/kg N_2O-N
GWP_{N2O}	=	Global warming potential for N_2O (Table 5.1)	tCO_2e/tN_2O

Equation 5.25. Nitrous Oxide Emissions from the Incorporation of All Crop Residues

$$\boldsymbol{N2O\_Nfix_{s,t} = \sum_{g}\left(MB_{g,s,t} \times N_{content,g}\right) \times EF_{Ndirect} \times \frac{44}{28} \times GWP_{N_2O}}$$

Where,

			Units
$N2O\_Nfix_{s,t}$	=	Nitrous oxide emissions from all crop residues (including those from N-fixing species) for stratum *s* in cultivation cycle *t*	tCO_2e
$MB_{g,s,t}$	=	Annual dry matter, including aboveground and below ground, of N-fixing species *g* returned to soils for stratum *s* in cultivation cycle *t*	t dm
$N_{content,g}$	=	Fraction of N in dry matter for plant species *g*	tN/t dm
$EF_{Ndirect}$	=	Emission factor for nitrous oxide emissions from N additions from synthetic fertilizers, organic amendments and crop residues	tN_2O / tN applied
44/28	=	Molar mass ratio of N_2O to N	kg N_2O/kg N_2O-N
GWP_{N2O}	=	Global warming potential for N_2O (Table 5.1)	tCO_2e/tN_2O

Equation 5.26. Nitrous Oxide Emission Reductions from Biomass Burning

$$\boldsymbol{\overline{\Delta N2O\_bb_{s,t}} = \overline{N2O\_bb_{bsl,s,t}} - \overline{N2O\_bb_{pr,s,t}}}$$

Where,

			Units
$\overline{\Delta N2O\_bb_{s,t}}$	=	Average nitrous oxide emission reductions from biomass burning in stratum *s* during cultivation cycle *t*	tCO_2e/acre
$\overline{N2O\_bb_{bsl,s,t}}$	=	Average baseline nitrous oxide emissions from biomass burning in stratum *s* during cultivation cycle *t* (Equation 5.27)	tCO_2e/acre
$\overline{N2O\_bb_{pr,s,t}}$	=	Average project nitrous oxide emissions from biomass burning in stratum *s* during cultivation cycle *t* (Equation 5.27)	tCO_2e/acre

Equation 5.27. Nitrous Oxide Emissions from Biomass Burning

$$\boldsymbol{\overline{N2O\_bb_{s,t}} = \frac{\sum_c\left(MB_{c,s,t} \times CF_c \times EF_{c,N_2O}\right)}{A_s} \times \frac{1}{10^6} \times GWP_{N_2O}}$$

Where,

			Units
$\overline{N2O\_bb_{s,t}}$	=	Average nitrous oxide emissions due to biomass burning in stratum *s* in cultivation cycle *t*	tCO_2e/acre
$MB_{c,s,t}$	=	Mass of agricultural residues of type *c* burned in stratum *s* in cultivation cycle *t*	kg
CF_c	=	Combustion factor for agricultural residue type *c*, based on proportion of pre-fire fuel biomass consumed	
$EF_{c,N2O}$	=	Nitrous oxide emission factor for the burning of agricultural residue type *c*	g N_2O/kg dry matter burnt
A_s	=	Area of stratum *s*	acres
$1/10^6$	=	Conversion factor	g/t
GWP_{N2O}	=	Global warming potential for N_2O (Table 5.1)	tCO_2e/tN_2O

5.4.3 Carbon Dioxide Emissions

The only quantified source of non-reversible carbon dioxide emissions in a soil enrichment project is the combustion of fossil fuels used in equipment (Equation 5.28). These emissions are calculated based on the total quantity of fuel used for each type of equipment and fuel. Where projects can show that the total CO_2 emissions from fossil fuels are *de minimis* (i.e., less than 5% of total baseline emissions for that reporting period), the project developer may propose an alternative estimation approach. The verifier shall confirm that such an approach is reasonable and conservative.

In addition, if the project developer can show that the fossil fuel emissions in the project scenario are expected to either remain the same or decline in relation to the baseline, this source may be excluded.

Equation 5.28. Carbon Dioxide Emission Reductions from Fossil Fuels

$$\overline{\Delta \boldsymbol{CO2\_NR_{s,t}}} = \overline{\boldsymbol{CO2\_NR_{bsl,s,t}}} - \overline{\boldsymbol{CO2\_NR_{pr,s,t}}}$$

Where,			Units
$\overline{\Delta CO2\_NR_{s,t}}$	=	Average carbon dioxide emission reductions from fossil fuel use in stratum *s* during cultivation cycle *t*	tCO_2e/acre
$\overline{CO2\_NR_{bsl,s,t}}$	=	Average baseline carbon dioxide emissions from fossil fuel use in stratum *s* during cultivation cycle *t* (Equation 5.29)	tCO_2e/acre
$\overline{CO2\_NR_{pr,s,t}}$	=	Average project carbon dioxide emissions from fossil fuel use in stratum *s* during cultivation cycle *t* (Equation 5.29)	tCO_2e/acre

Equation 5.29. Carbon Dioxide Emissions from Fossil Fuels

$$\overline{\boldsymbol{CO2\_NR_{s,t}}} = \frac{\sum_j \left(\boldsymbol{FFC_{j,s,t}} \times \boldsymbol{EF_{CO_2,j}}\right)}{\boldsymbol{A_s}}$$

Where,			Units
$\overline{CO2\_NR_{s,t}}$	=	Average carbon dioxide emissions from fossil fuel use in stratum *s* during cultivation cycle *t*	tCO_2e/acre
$FFC_{j,s,t}$	=	Consumption of fossil fuel in vehicle/equipment type *j* for stratum *s* in cultivation cycle *t*	gal
$EF_{CO2,j}$	=	Emission factor for the type of fossil fuel *j* combusted	tCO_2e/gal
j	=	Types of fossil fuels	
A_s	=	Area of stratum *s*	acres

5.5 Emissions from Leakage

This protocol offers robust mechanisms to account for any market-shifting leakage associated with reductions in livestock management or crop yield on project lands. Any such changes will be assessed at the field level, and then aggregated to the project level. Any significant drops in crop yields or livestock management, will result in reductions to emission reductions issued for the project, to account for such changes.

Where yield of a given crop drops on project fields, as a result of project activities, it is considered market-shifting 'leakage', or a secondary effect of the offset project. The principle of leakage suggests that in such circumstances there will be a proportionate increase in yield elsewhere, as the market reacts to the drop in supply, and so the associated GHG impacts are simply shifted, not eliminated – they 'leak' outside of the project boundary. In such circumstances it is often seen as best practice to require the project to artificially increase their yield for the given reporting period, so that they account for GHG emissions that would otherwise leak outside of the project. This protocol provides robust accounting mechanisms to ensure any potential market-shifting leakage, in the form of declines in reporting period crop yield or livestock, are accounted for. This protocol seeks to provide additional protection from specific scenarios where leakage would be most likely, if it were to occur at all:

Scenario 1: Displacement of livestock outside of the project area
Scenario 2: Sustained decline in harvested yield for crops grown in the project area

These scenarios are only relevant for fields which employ livestock grazing and/or produce crop harvests. Project activities on other fields are categorically not expected to result in emissions leakage. While the mechanisms noted above are included to account for market-shifting leakage, as discussed in Appendix C, the Reserve believes soil enrichment projects are unlikely to result in market-shifting leakage so long as the project area remains in commodity crop production. Moreover, research indicates that the project activities should not have long-term negative impacts on crop yields. Thus, the risk of market-shifting leakage is low for soil enrichment projects.

5.5.1 Accounting for Leakage from Livestock Displacement

This protocol offers robust mechanisms to account for any market-shifting leakage associated with reductions in livestock management on project lands. Any such changes will be assessed at the field level, and then aggregated to the project level. The level of grazing activity used to quantify project emissions may not be lower than the average level of grazing activity in the historic baseline period. Livestock populations must be monitored in the project scenario in order to quantify project emissions from grazing activities (the calculation of CH_4 from enteric fermentation and manure deposition, as well as the calculation of N_2O from manure deposition). The level of grazing activity, as a function of both population and grazing time, is also used to account for potential leakage associated with the displacement of grazing activities to areas outside of the project boundaries relative to baseline levels. To avoid crediting for emission reductions which correspond with emissions leakage (i.e., lowering of CH_4 and N_2O emissions from grazing within the project area relative to the baseline, resulting in increased grazing activities elsewhere to maintain overall production levels within the greater market), the level of grazing activity used to quantify project emissions may not be lower than the average level of grazing activity in the historic baseline period. Thus, if livestock displacement occurs, those emissions will continue to be counted in the project scenario as emissions leakage.

For projects using the default equations, this is monitored as animal grazing days (or AGD). The average AGD for the historical baseline period shall represent the minimum bound for the value of AGD used when calculating the *project scenario* emissions in Equation 5.11b, Equation 5.13b, Equation 5.23, and Equation 5.24. This mechanism should allow for simple means to accurately assess changes in livestock managed on project lands. The Reserve chose these mechanisms, as opposed to more directly attempting to monitor feed quality (i.e., changes in forage quality) due to their simplicity. Additionally, given the focus of project activities on enhancing ecosystem health, the Reserve feels there is a low risk that project activities will result in a decline in forage health on project lands.

For projects employing models to estimate grazing emissions, the inputs will include population and some form of time (either days or hours). These will be averaged for the historical baseline period in units appropriate to the model being employed, and used when calculating the *project scenario* emissions as represented in Equation 5.11a, Equation 5.13a, and Equation 5.18a.

5.5.2 Accounting for Leakage from Yield Reduction of Crops

This protocol offers robust mechanisms to account for any market-shifting leakage associated with reductions in crop yields on project lands. Any such changes will be assessed at the field level, and then aggregated to the project level. If leakage in crop production is detected in any reporting period using Equation 5.30 - Equation 5.33 below, then a deduction will be applied to all reversable and non-reversable emission reductions for the reporting period using Equation 5.2 and Equation 5.6 respectively. If crops grown within the project area experience significant, prolonged yield decline, the market could shift the related emissions through increased production outside of the project area. In order to mitigate this type of leakage, it is important to monitor the yield of crops produced in the project area. Each major category of crop shall be assessed separately (e.g., corn, wheat, rice, etc.).

For major crops in the U.S. which are supported by crop insurance programs, farmers report a long-term yield metric known as the Actual Production History (APH). These are also the crops with the greatest risk of resulting in market-shifting leakage due to yield decline within the project area. APH is a useful metric for the assessment of yield over time because it is calculated according to established government methods, and it must be reported to the government in order to receive crop insurance. This results in transparency and verifiability.

In order to assess the risk of market-shifting leakage within the project, the project developer shall report the average APH across all acres of each crop within each cultivation cycle. If, for any given crop, in a given cultivation cycle, the difference between the project area APH and the regional average APH for the same crop, calculated as a “yield ratio,” declines by more than 5 percentage points, as compared to the average yield ratio for that crop during the historical baseline period, all emission reductions (both reversible and non-reversible) from strata containing fields producing that crop shall be discounted by that number of percentage points exceeding the threshold until a cultivation cycle where the difference between the project APH and the regional average APH for that crop no longer exceeds this threshold. The reduction is proportional to the area of the stratum growing a particular crop. The regional average APH used for this comparison must be sourced from the smallest geographic or political unit for which such data are available, then weighted by the acreage of the project area within each of those units which are growing crop *c* in the relevant year.

Given the timing of APH calculation and submission for Federal crop insurance programs, it is possible that these data will not yet be available for the project area for the crops grown during the reporting period. Given that leakage is not an instantaneous phenomenon, and that APH is, itself, a long-term average of yield, it is acceptable for the APH data used in the leakage calculation to be one year behind the project reporting cycle. However, if current year APH data are available in sufficient time for the verification activities, they must be used.

Equation 5.30. Deduction for Leakage due to Yield Decline in Crops

$$\boldsymbol{LE_t = MAX\left(0, \sum_c \left(\overline{YR_{bsl,c}} - YR_{c,t}\right) \times \left(\frac{A_{c,t}}{\sum_c A_{c,t}}\right) - 0.05\right)}$$

Where,			Units
LE_t	=	Leakage deduction for yield decline of crop *c* during cultivation cycle *t*	
$\overline{YR_{bsl,c}}$	=	Average yield ratio for crop *c* during the historical baseline period	
$YR_{c,t}$	=	Project-specific yield ratio for crop *c* during cultivation cycle *t*	
$A_{c,t}$	=	Area of fields growing crop *c* during cultivation cycle *t*	acres

Equation 5.31. Project-Specific Crop Yield Ratio in the Project Scenario

$$\boldsymbol{YR_{c,t} = \frac{\overline{APH_{c,t}}}{\overline{APH_{RA,c,t}}}}$$

Where,			Units
$YR_{c,t}$	=	Project-specific yield ratio for crop *c* during cultivation cycle *t*	
$\overline{APH_{c,t}}$	=	Average APH reported by fields growing crop *c* during cultivation cycle *t*	Bu/ac
$\overline{APH_{RA,c,t}}$	=	Regional average APH for crop *c* during cultivation cycle *t*	Bu/ac

Equation 5.32. Average Yield Ratio During the Historical Baseline Period

$$\boldsymbol{\overline{YR_{bsl,c}} = \frac{\sum_{hy} \overline{APH_{c,hy}}}{\sum_{hy} \overline{APH_{RA,c,hy}}}}$$

Where,			Units
$\overline{YR_{bsl,c}}$	=	Average yield ratio for crop *c* during the historical baseline period	
$\overline{APH_{c,hy}}$	=	Average APH reported by fields growing crop *c* during cultivation cycle *hy* of the historical baseline period	Bu/ac
$\overline{APH_{RA,c,hy}}$	=	Regional average APH for crop *c* during cultivation cycle *hy* of the historical baseline period	Bu/ac

The weighting approach employed in Equation 5.33 shall be employed not only for the averaging of project APH in the baseline scenario, but also for the averaging of the APH in the project scenario ($\overline{APH_{c,t}}$), and the regional average APH values ($\overline{APH_{RA,c,t}}$ and $\overline{APH_{RA,c,hy}}$), according to the number of acres in the project area of the relevant region, growing crop *c* in the relevant year. Thus, for example, if government APH data are available at the county level, the project's "regional average" would be built from these county-level figures, weighted by the number of project acres growing crop *c* in each county during the relevant year.

Equation 5.33. Average Annual Crop Yield During the Historical Baseline Period

$$\overline{\boldsymbol{APH_{c,hy}}} = \frac{\sum_f \left(\boldsymbol{APH_{f,c,hy}} \times \boldsymbol{A_{f,c,hy}}\right)}{\sum_f \boldsymbol{A_{f,c,hy}}}$$

Where,			Units
$\overline{APH_{c,hy}}$	=	Average APH reported by fields growing crop *c* during cultivation cycle h*y* of the historical baseline period	Bu/ac
$APH_{f,c,hy}$	=	APH for field *f* growing crop *c* during cultivation cycle *hy*	Bu/ac
$A_{f,c,hy}$	=	Area of field *f* growing crop *c* during historical cultivation cycle *hy*	acres

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 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 6.4 will be collected and recorded.

At a minimum, the Monitoring Plan shall include the following details:

1. A general description of the project, including number of fields and location information
    a. The project monitoring plan will be a public document, so projects may request that information relating to the location of specific fields be redacted
2. A description of practice changes implemented
3. A description of how the eligibility requirements are met
    a. 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) and maintains regulatory compliance (Section 3.6)
    b. Details on the baseline determination
    c. A description of how permanence requirements will be met
4. Frequency of data acquisition
    a. The frequency of data monitoring will depend on both the nature of the metric being monitored (e.g., fertilizer applications, crop type) as well as the method employed for data collection (e.g., paper logs, smartphone applications, machine data, etc.). At a minimum, the data required for quantification of soil enrichment projects shall be monitored and recorded (or documented, as appropriate) for each cultivation cycle
5. A record keeping plan (see Section 7.1 for minimum record keeping requirements)
6. The frequency of instrument cleaning, inspection, field check, and calibration activities (if relevant)
7. The role of individuals performing each specific monitoring activity
8. QA/QC provisions to ensure that data acquisition and meter calibration are carried out consistently and with precision (where relevant)
    a. Project developers are responsible for monitoring the performance of the project and ensuring that the operation of all project-related equipment is consistent with the manufacturer's recommendations
9. Modeling plan, if applicable
    a. The project monitoring plan will identify the model(s) selected initially and document analysis and results demonstrating validation of the model(s). Model validation datasets will be archived to permit periodic application to calculate model structural uncertainty. The modeling plan will detail all required model input parameters and specify the baseline schedule of agricultural management activities for each sample unit
10. A description of each monitoring task to be undertaken, and the technical requirements therein
11. Parameters to be measured, including any parameters required for the selected model (additional to those specified in this methodology)

   a. At a minimum, soil enrichment projects must monitor the data listed in Table 6.1. However, depending on the practices adopted and the model selected, additional data or parameters may be required to be monitored. Guidance for monitoring of SOC through direct sampling and testing is provided in Section 6.5

12. Data to be collected and data collection techniques and sample designs for directly sampled parameters
13. Data archiving procedures
14. Roles, responsibilities, and capacity of monitoring team and management

The Reserve will make available a Monitoring Plan template that includes sections for all required information. Use of the template is not required, but is strongly recommended.

6.1 Agricultural Management Data Collection

For each year of the project, as well as each year of the historical baseline period, $t = -1$ to $t = -x$, the following required information on agricultural management practices (where applicable) will be determined (Table 6.1). These minimum data requirements encompass critical and sensitive inputs into biogeochemical models and may require model-specific adjustments when used to quantify SEP projects. For example, plant and harvest dates may be input on a specific day, or may be input within a specific month, depending on whether the model runs on a daily or a monthly timestep. Animal stocking rates offer another example, which may be input directly in some models, while others may first require a conversion to grazing intensity on plant biomass before being input into the model. The conversion of qualitative and quantitative data described in Table 6.1 into model inputs should be clearly described in the Monitoring Plan.

The guidance of this section also applies to the collection of data to be used as inputs to the equations in this protocol which are not reliant on the use of external models.

Table 6.1. Minimum Data Parameters for Soil Enrichment Projects

Agricultural Management Practice	Qualitative Data	Quantitative Data
Crop	▪ Crop type(s)	▪ Approximate date(s) planted (if applicable) ▪ Approximate date(s) harvested / terminated (if applicable)
Soil amendments	▪ Manure (Y/N) ▪ Other organic amendments (such as compost, biosolids etc.) (Y/N) ▪ Synthetic N fertilizer (Y/N) ▪ Crop residue removal approach: o Minimal residue removal, e.g., grain only harvest o Partial residue removal, e.g., baled straw o Maximum residue harvest, e.g., silage	▪ Manure application rate (if applicable) ▪ Other organic amendment application rate (such as compost, biosolids etc., if applicable) ▪ Synthetic N fertilizer application rate (if applicable)
Irrigation or other hydrological management	▪ Irrigation (Y/N) ▪ Flooding (Y/N)	▪ Irrigation rate (if applicable)
Tillage	▪ Tillage (Y/N)	▪ Depth of tillage (if applicable)

Agricultural Management Practice	Qualitative Data	Quantitative Data
Grazing	▪ Grazing (Y/N) ▪ Animal type (if applicable)	▪ Animal stocking rate (if applicable)

This list above is intended to be indicative of model data requirements for activities that (i) could foreseeably contribute to GHG emission reductions, and (ii) the impacts of which could foreseeably be modeled using this protocol. Individual models may have additional or different data requirements.

Qualitative information on agricultural management practices will be determined either via consultation with, and substantiated with a signed attestation from, the Field Manager of the sample field during the reporting period, or through evidence of direct monitoring (e.g., remote sensing of crop types, time-stamped photos of equipment).

The source of quantitative information on agricultural management practices, and any additional quantitative inputs for the baseline and project scenarios where required by the model selected or by the equations in Section 5, shall be chosen based on the guidance in this section.
It is to be expected that a range of alternative sources will be needed to compile sufficient data. Extrapolation is also expected and allowed, where data for parameters is not forthcoming. Some examples of forms of extrapolation that may be permissible include the use of regional average values, regionally appropriate ranges, ranges developed using project-specific data, ranges developed using proprietary data, datapoints supported by independent expert opinion or literature.

Each project is required to develop and seek Reserve approval for a methodology for quality assurance / quality control (QA/QC) for their data. The data QA/QC methodology must be developed to ensure the selected data sources do not lead to an overestimation of emission reductions. The methodology must also explicitly address whether the given parameter is relevant for establishing additionality for the given field. The QA/QC methodology must include a sensitivity analysis for each data input on emission reduction results including with respect to any model chosen for use for the given reporting period. The higher the impact the given parameter has on emission reductions, the higher the level of veracity that is needed for the given input. Any inputs that affect emission reductions in a material way require more robust and/or multiple sources of evidence. The QA/QC methodology must contain safeguards employed with respect to extrapolation, some process for validating / verifying any logic/code used tin software to automate implementation, analysis of the impacts on emission reductions resulting from implementation of the methodology, and a summary of sources. The data QA/QC methodology shall be reviewed and approved by the Reserve prior to verification.

Data sources that are likely to be approved by the Reserve include the following:

1. Data sourced from the Field Manager, related to the project field(s), and supported by one of the following categories (in order of priority from higher to lower):

    a. Historical management records supported by one or more forms of documented evidence pertaining to the selected sample field and timeframe (e.g., management logs, receipts or invoices, farm equipment specifications, logs or files containing machine and/or sensor data), or remote sensing (e.g., satellite imagery, manned aerial vehicle footage, drone imagery), where requisite information on agricultural management practices can be reliably determined with these methods (e.g., tillage status, crop type, irrigation). With respect to remote sensing, it should be noted that such evidence would likely be highly useful to detect relevant practice change, but in and of itself would not be used to quantify the GHG impacts of such change.

b. Historical management plans supported by one or more forms of documented evidence pertaining to the selected sample field and timeframe (e.g., management plan, recommendations in writing solicited by the farmer or landowner from an agronomist). Where more than one value is documented in historical management plans (e.g., where a range of application rates are prescribed in written recommendations), the principle of conservatism will be applied, selecting the value that results in the lowest expected emissions (or highest rate of stock change) in the baseline scenario.

c. Signed attestation from the Field Manager, supported by either: other evidence-supported values for similar fields (e.g., data from adjacent fields with the same crop, adjacent years of the same field), government data of application rates in that area, values from published literature relevant to that crop and Land Resource Region or statement from a local extension agent regarding local application rates.

2. Where data are not available from the Field Manager for a specific field, values may be gap-filled using regional (sub-national) average values derived from agricultural census data or other sources from within a period preceding the start date of either 20 years or the most recent 10-year iteration of that dataset, whichever is more recent, referencing the relevant crop or ownership class where estimates have been disaggregated by those attributes. Examples include the U.S. Department of Agriculture (USDA) National Agricultural Statistics Service (NASS) Quick Stats database[21] and USDA Agricultural Resource Management Survey (ARMS),[22] or relevant, published, peer-reviewed studies. Projects should use as spatially fine data as possible for this purpose, and demonstrate sufficient geographic proximity of such data to the project fields. That is, where data from the given county are reasonably available, that should be used, otherwise data from the given state or Land Resource Region may be acceptable. Using such data for gap-filling on a geographically diverse, aggregated project will present different challenges and constraints as compared to a small, localized SEP project.

6.2 Monitoring Ongoing Eligibility and Permanence

To maintain eligibility on an ongoing basis, soil enrichment projects must demonstrate that the project area continues to meet the requirements of Section 2 during the reporting period. This includes monitoring of land use, which may be evidenced through a site visit or via remote sensing. With respect to remote sensing, and other monitoring techniques, it should be noted that such evidence would likely be highly useful to detect relevant practice change, but in and of itself would not be used to quantify the GHG impacts of such change. Monitoring for the permanence of SOC stocks involves assessment of disturbance of the soil itself. Permanence of SOC stocks may be threatened by discrete disturbance events, such as catastrophic erosion due to flooding, or by long term management changes.

[21] https://quickstats.nass.usda.gov.
[22] https://www.nass.usda.gov/Surveys/Guide_to_NASS_Surveys/Ag_Resource_Management/index2.php.

Monitoring during the crediting period that meets the requirements of this protocol for the quantification of emission reduction is sufficient for the identification of potential reversals. Monitoring during the permanence period should be capable of identifying the following potential sources of reversals:

- Land use change
- The presence or absence of tillage
- Extended fallow periods
- Extensive areas of continuously exposed ground

In the event of drought taking place during the permanence period, particularly where similar drought conditions were not experienced during the crediting period, it may be necessary to undertake monitoring of management activities to ensure they are appropriate for maintaining SOC during drought conditions.

6.3 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 (Derner, 2007), overgrazing can be detrimental to both the storage of soil carbon (Linghao, 1997) and the health of the grassland ecosystem (McGranahan, 2013). 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 (Holecheck, 1988) (Holechek, Gomes, Molinar, Galt, & Valdez, 2000).

Soil enrichment projects must employ a mechanism to detect and prevent overgrazing on project lands, which is tailored to the specific conditions of their project and its ecosystem. It is up to each project developer to determine the appropriate means to safeguard the project against overgrazing. During the report period, evidence and data collected with respect to measuring project practices (as set out below and elsewhere) should be sufficient to ensure overgrazing does not occur, or to account for any such impacts. During the permanence period additional monitoring should be employed (see Section 7.6.1).

For each reporting period, Project Owners must provide both a quantitative and qualitative accounting of grazing activities for the reporting period. In terms of quantitative data, projects must document the type of livestock being grazed and the total animal grazing days for each type (Box 5.3). The livestock shall be categorized according to the categories in the *SEP Parameters* spreadsheet.[23] These data are used for the parameter AGD_l in Equation 5.11, Equation 5.13, Equation 5.23 and Equation 5.24.The frequency of monitoring and the form of the documentation is not prescribed by this protocol. In terms of qualitative reporting, project developers shall include in their monitoring report a description of grazing activity for the reporting period.

Examples of documentation that may suffice to demonstrate the quantitative grazing monitoring requirements may include (this list is not comprehensive nor is it intended to define sufficiency of documentation):

[23] Available at: http://www.climateactionreserve.org/how/protocols/soil-enrichment/.

- 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

In addition, the Reserve may conduct additional review to confirm that a reversal has not occurred due to overgrazing.

6.4 Monitoring Project Emission Sources

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 fertilizer applied (other than manure from grazing), by type
- Nitrogen content of fertilizer applied, by type
- Purpose, type, and quantity of fossil fuels used (e.g., tractor, diesel, 100 gallons)

For project fields that employ fertilizer additions, it is strongly encouraged that the fertilizer application on those fields is guided by a nutrient management plan. Nutrient management plans should consider the principles contained in NRCS Conservation Practice Standard 590 for Nutrient Management.[24] Where a project also incorporates irrigation, grazing, and/or the use of nitrogen fixing crops, such activities should be considered in developing any nutrient management plan for the project. Development of and adherence to a nutrient management plan is not required, but is strongly recommended.

For fossil fuel emissions (Equation 5.28), if the Project Owner can demonstrate that the total value of $CO2\_NR_{s,t}$ 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 approved alternative method, the monitoring of fossil fuels as described in this section is not required.

6.5 Soil Sampling and Testing Guidance

Direct measurement of soil organic carbon levels must be performed via soil sampling to establish values to be used as the basis for baseline modeling and, as applicable, project modeling, as well as for ongoing updates to sampled soil organic carbon levels required at least every five years. SOC measurement will by necessity include calculation of SOC based on bulk density, as well as the determination of SOC stocks based on either %C by mass, or use of the equivalent soil mass method. Project owners must provide documentation describing the soil sampling and laboratory analysis methods employed to estimate soil carbon stocks. While this protocol does not require specific soil sampling and laboratory analysis methods to be used, it does require that a set of minimum standards be met, as outlined in the following sections, and that statistical uncertainty associated with sampling be quantified, as described in Section 5.2, to moderate the crediting outcomes derived from soil organic carbon stocks. Confidence deductions are applied to estimated changes in carbon stocks at increasing rates as statistical uncertainty, including uncertainty associated with sampling, increases.

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[24] Available at: http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/stelprdb1046896.pdf.

6.5.1 Sample Design and Soil Collection

Since the approach to sampling soil organic carbon levels will vary from project to project, Project Owners must describe their sampling approach in the Monitoring Plan. Regardless of the exact approach used, all projects must adhere to the minimum standards identified in Table 6.2. The application of this protocol will often result in the use of a multi-stage sample design (i.e., two or more stages), at a minimum incorporating the primary sample unit and sample points (e.g., aggregate soil cores) within sample units as the secondary unit. This approach may be expanded to incorporate a range of other sampling approaches to improve efficiency, e.g., pre- or post-stratification, variable probability sampling (e.g., probability proportional to area), etc.

For all directly sampled parameters, the project Monitoring Plan will clearly delineate spatially the sample population and specify sampling intensities, selection of sample units and, as applicable, locations of sample points within sample units (and control sites). In addition to the minimum standards outlined in Table 6.2, Project Owners are advised to consider the verification guidance in Section 8.4 associated with verification of soil organic carbon sampling prior to settling on a sample design. Project Owners should demonstrate to their verifiers' satisfaction (and verifiers should use professional judgment to satisfy themselves) that persons undertaking soil sampling have sufficient understanding of these minimum standards to be able to carry out this work effectively.

Fields which continuously (i.e., more than once for the same crop) tilled to depths deeper than 20 cm in their historical baseline period, and then go on to employ no-till in their project scenario, will not be eligible to be credited for SOC gains. See Section 3.4.1.3 for requirements on setting the baseline. Such fields are excluded from eligibility to generate credits from SOC gains, as there is a risk of possible migration of material levels of SOC from the soil profile below 30 cm depth, if sampling to 30 cm. Most tillage practices are typically employed at 10-20 cm depth, therefore a sample to 30 cm will capture possible migration of SOC in the soil profile 10-20 cm below historical plow depth. Fields historically employing deep tillage practices (i.e., tillage to depths deeper than 20 cm) may become eligible to be credited for SOC gains if/when they subsequently adopt any tillage practice other than no-till in subsequent reporting periods. For each field that employed historical tillage practices, and then move to employing no-till in the reporting period, projects must provide evidence of historical plow depth to determine if they will be eligible to be credited for SOC changes. See Appendix B.1 for further discussion of these issues.

Table 6.2. Minimum Standards for Sampling Soil Organic Carbon

<table>
<tr><th>Category</th><th>Guidance</th></tr>
<tr><td>Sample units and stratification</td><td>
▪ The points for soil sampling must be selected randomly according to a sample design, following the guidance in this section and Appendix D.
▪ Each stratum must contain at least 3 sample points
▪ All projects must employ either pre- or post-stratification of primary sample units (and any sample stages above the stage based on sample points).
▪ The governing rules for stratification of primary sample units and stratification methodology must be described. The process for updating strata must be described.
▪ Stratification may be based on the following:
o Adopted practice change(s)
o Bulk density
o Soil texture
o Soil series
o Precipitation (e.g., mean annual)
o Temperature (e.g., mean annual)
o Land Resource Region
o Aridity index
o Soil wetness index
o Indicator variable for whether the land was flooded
o Slope
o Aspect
▪ Stratum areas must be provided at verification with maps and tabular outputs.
▪ Sample units in the stage directly above sample point stage must be selected for sampling on a randomized basis during initial sampling, with the randomized list of all sample units retained for verification. If a selected unit is unable to be sampled (e.g., either due to weather constraints or because post-planting sampling could negatively impact the crop), the Project Owner must justify why the unit was not sampled. They may also choose to randomly select another unit to sample in lieu of the unsampled unit to maintain their desired sample size.
</td></tr>
<tr><td>Sample location</td><td>
▪ Geographic locations of intended sampling points must be established prior to sampling.
▪ The location of both the intended sampling point and the actual sampling point must be recorded.
▪ Geotagged photographs should be made available for verification
▪ Remeasurement of previously sampled points during subsequent reporting periods is allowed, though remeasured sample points may comprise no more than 50% of the total number of sample plots. Furthermore, either the selection of sample points to be remeasured or the selection of sample units in the stage directly above the sample point stage and containing the potential sample points for remeasurement must occur on a randomized basis.
</td></tr>
<tr><td>Site preparation</td><td>
▪ All organic material (e.g., living plants, crop residue) must be cleared from the soil surface prior to soil sampling.
</td></tr>
</table>

Category	Guidance
Sample depth	▪ Minimum of 30 cm (the Reserve recommends sampling to 1 m). ▪ Projects may only be credited with respect to SOC gains to depths up to or less than the depth of their original baseline sample. If a project seeks to be credited to a depth below their original baseline SOC sample, approval must be given by the Reserve. If soils are sampled below 30 cm, it is advised that they are split into at least two depth increments to distinguish changes in the upper and lower portions of the soil profile. If the model employed by the project is not capable of projecting changes to SOC below 30 cm, samples must be split into at least two depth increments, with the upper portion (30 cm) used for initial modeling. All soil samples must be subject to verification in the reporting period in which they were sampled. In the case of samples to depths deeper than 30 cm that are intended for future use, such samples must also be subject to verification in the reporting period in which they are taken, in order for them to be eligible to be used to generate credits in future. ▪ Data for the lower portion(s) may be retained for potential future use, though actual soil samples may be discarded. If models become capable of projecting changes in SOC at depths deeper than 30 cm in the future, verified data retained from such lower depths can be used to quantify emission reductions, and CRTs may be issued in the first reporting period for which such modeling is available.
Sample handling	▪ If multiple cores are composited to create a single sample, these cores must all be from the same depth and be fully homogenized prior to subsampling. ▪ Soils must be shipped within 5 days of collection and should be kept cool until shipping.

6.5.2 Laboratory Analysis

As with soil sampling, the exact methods used to analyze soil samples will vary between projects. Nevertheless, Project Owners must describe in the Monitoring Plan the laboratory analysis methods used to determine soil carbon levels, adhering to the minimum standards outlined in Table 6.3.

Project Owners must ensure that any laboratory used for soil enrichment projects can demonstrate proficiency having taken part in the North American Proficiency Testing Program (NAPTP) for laboratories that provide soil sampling analysis, and in particular the voluntary Performance Assessment Program (PAP), offered as a part of the NAPTP.[25] Where state accreditation programs are available, relating specifically to soil testing, Project Owners are strongly encouraged to use laboratories with such accreditation.

[25] Details on the NAPTP and the PAP can be found on the NAPTP website, here: https://www.naptprogram.org/.

Table 6.3. Minimum Standards for Laboratory Analysis of Soil Samples

Category	Guidance
General Soil Sample Preparation	▪ Soils must be dried within 48 hours of arrival at lab or kept in refrigeration. ▪ Soil aggregates must be broken apart by manual or mechanical means (so long as such methods break soil clumps but do not pulverize rocks) and soils sieved to < 2 mm. All soil carbon analysis should be performed on the fine (< 2 mm) fraction only. ▪ If bulk density methods are being used to convert soil carbon concentration to soil carbon stocks, coarse (>2 mm fraction) content corrections to bulk density must be made. All soil samples must be reviewed during verification of the reporting period in which they were sampled. Data for the lower portion(s) may be retained for potential future use, though actual soil samples may be discarded.
Analysis Technique	▪ Soil carbon analysis must be performed using dry combustion techniques. Unless and until approved by the Reserve at a later date, Loss on Ignition and Walkley-Black methods may not be used under this protocol since they do not provide the necessary accuracy and precision for soil carbon measurements as of the date of protocol adoption. The Reserve will continue to work with stakeholders to develop guidance for practically controlling for accuracy, precision, and handling of outliers to enable the use of other testing methods, such as spectroscopy. ▪ If using dry combustion to quantify soil organic carbon, any inorganic carbonates must be accounted for using either (1) an acid pretreatment prior to dry combustion analysis or (2) quantification of carbonates using a pressure calcimeter or IR spectroscopy. ▪ Standards and duplicate samples should be run routinely to characterize within-run and between-run precision.

6.6 Modeling Guidance

This protocol does not mandate the use of any specific model, instead it specifies below minimum requirements any model must demonstrate before being approved by the Reserve for use under this protocol. Nonetheless, the Reserve can advise that models that appear suitable, in the sense that they are likely to meet the minimum requirements below, are likely to include COMET-Farm and DNDC.

Models used to estimate stock change/emissions may be empirical or process-based, and must meet the following conditions:

1. Publicly available;
2. Shown in at least one peer-reviewed study to successfully simulate changes in soil organic carbon and, where modeling is used for non-reversible emissions impacts, trace gas emissions resulting from changes in agricultural management included in the project description;
3. Able to support repeating the project model simulations. This includes clear versioning of the model use in the project, stable software support of that version, as well as fully reported sources and values for all parameters used with the project version of the model. In the case where multiple sets of parameter values are used in the project, full reporting includes clearly identifying the sources of varying parameter sets as well as how they were applied to estimate stock change/emissions in the project. Acceptable sources include peer-reviewed literature and appropriate expert groups, and must

describe the data sets and statistical processes used to set parameter values (i.e., the parameterization or calibration procedure, see guidance described in 5);
4. Incorporate one or more input variables that are monitored ex-post;
5. Validated according to the guidance contained in the *Requirements and Guidance for Model Calibration, Validation, Uncertainty, and Verification for Soil Enrichment Projects* (*Model Requirements and Guidance* document), using the same parameters or sets of parameters applied to estimate SOC/trace gas emissions in the project.[26]

The same model(s) version(s) and parameters/parameter sets must be used in both the project and baseline scenarios. Model input data must be derived following guidance in Table 6.4. Model uncertainty must be quantified following guidance in Appendix D. Models may be recalibrated or revised based on new data, or a new model applied, providing the above requirements are met. Guidance is provided in Section 8.3 on requirements for verification of the proper use of models.

[26] Available for download at: https://www.climateactionreserve.org/protocols/soil-enrichment/.

6.7 Monitoring Parameters

Prescribed monitoring parameters necessary to calculate baseline and project emissions are provided in Table 6.4. Where a project is able to choose from various sources, the most accurate data should always be used first, followed by the most conservative option, and where unavailable, alternative options be used. Project Developers may use alternative values to the referenced parameters in Table 6.4, in particular those given in the Parameters Spreadsheet. The condition to use alternative values is dependent on the Reserve's prior approval.

Table 6.4. Soil Enrichment Project Monitoring Parameters

Eq. #, Box Reference	Parameter	Description	Data Unit	Calculated (c) Measured (m) Reference (r) Operating Records (o)	Measurement Frequency	Description
	Regulations	Monitoring of regulations relevant to project activities		n/a	Each verification cycle	Information used to: 1) To demonstrate ability to meet the legal requirement test – where regulation would require soil enrichment project activities 2) To demonstrate compliance with associated environmental rules, e.g., criteria pollutant emission standards, health and safety, etc.
Box 5.1	$\overline{\Delta G_t}$ and $\overline{G_t}$	Average emission reductions and average emissions, respectively from pool or source G in cultivation cycle t	tCO_2e/ac	m or c	Each reporting period	Calculated from modeled or measured values in the project area. The average emission reductions from pool or source G, or from changes in the stock of pool G, at time t are estimated using unbiased statistical approaches, such as from: Cochran, W.G. (1977). Sampling Techniques: 3d Ed. New York: Wiley. It is understood that application of this methodology may employ sample units of unequal sizes, which would necessitate proper weighting of samples in deriving averages. A range of sample designs (e.g., simple random samples, stratified samples, variable probability samples, multi-stage samples) may be employed.

Eq. #, Box Reference	Parameter	Description	Data Unit	Calculated (c) Measured (m) Reference (r) Operating Records (o)	Measurement Frequency	Description
Equation 5.2Equation 5.6, Equation 5.30	LE_t	Leakage deduction during cultivation cycle *t*	ratio	c	Each reporting period	See Section 5.5.2 for guidance.
Equation 5.3Equation 5.6Equation 5.15Equation 5.18Equation 5.27Equation 5.29	A_s	Area of stratum *s*	acres	m	Each reporting period	Delineation of the stratum area may use a combination of GIS coverages, ground survey data, remote imagery (satellite or aerial photographs), or other appropriate data. Any imagery or GIS datasets used must be geo-registered referencing corner points, clear landmarks or other intersection points. This value will be updated with each reporting period as fields are added or removed, or stratification is adjusted.
Equation 5.9Equation 5.11Equation 5.13Equation 5.18	$VarA_{s,t}$, $VarB_{s,t}$, $VarC_{s,t}$, etc.	Value of model input variable A, B, C, etc. for stratum *s* in cultivation cycle *t*	Units unspecified	o	Each reporting period	Biogeochemical model input variables. See Section 3.4.1.3 for data requirements. Relevant for both the baseline and project scenarios.
Equation 5.9Equation 5.11Equation 5.13Equation 5.15	GWP_{CH4}	Global warming potential for CH_4	tCO_2e/tCH_4	r	Each reporting period	Unless otherwise directed by the Reserve, this protocol requires that CH_4 must be converted using the 100-year global warming potential derived from the IPCC Fourth Assessment Report. Reproduced in the project parameters spreadsheet available at http://www.climateactionreserve.org/how/protocols/soil-enrichment/
Equation 5.11Equation 5.13Equation 5.23Equation 5.24	$AGD_{l,s,t}$	Grazing days in stratum *s* for each livestock type *l* in year *t*	Number of days	o	Each reporting period	See Section 3.4.1.3 for data requirements.
5.11b	VS_l	Volatile solids excreted by grazing animals in category *l*	kg VS/animal/day	r	Each reporting period	Referenced for the project site state based on default tables in the project parameters spreadsheet available at http://www.climateactionreserve.org/how/protocols/soil-enrichment/

Eq. #, Box Reference	Parameter	Description	Data Unit	Calculated (c) Measured (m) Reference (r) Operating Records (o)	Measurement Frequency	Description
5.13	$PEF_{ent,l}$	Project emission factor for enteric methane emissions from livestock category *l* in the project state	kg CH_4/(head *x* day)	r	Each reporting period	Referenced for the project site state based on default tables in the project parameters spreadsheet document at http://www.climateactionreserve.org/how/protocols/soil-enrichment/
5.15, Equation 5.27	CF_c	Combustion factor for agricultural residue type *c*	Proportion of pre-fire fuel biomass consumed	r	Once	The combustion factor is selected based on the agricultural residue type burned. Referenced from the default tables in the project parameters spreadsheet available at http://www.climateactionreserve.org/how/protocols/soil-enrichment/
5.15	$EF_{c,CH4}$	Methane emission factor for the burning of agricultural residue type *c*	g CH_4/kg dry matter burnt	r	Once	The emission factor is selected based on the agricultural residue type burned. Referenced from the default tables in the project parameters spreadsheet available at http://www.climateactionreserve.org/how/protocols/soil-enrichment/
Equation 5.15Equation 5.27	$MB_{c,s,t}$	Mass of agricultural residues of type *c* burned in stratum *s* in cultivation cycle *t*	kg	r	Each reporting period	Either model results, IPCC or government estimation methods, or peer-reviewed published data may be used to estimate the aboveground biomass prior to burning. It is conservatively assumed that 100% of aboveground biomass is burned.
Equation 5.18Equation 5.20Equation 5.21Equation 5.23Equation 5.24Equation 5.25Equation 5.27	GWP_{N2O}	Global warming potential for N_2O	tCO_2e / tN_2O	r	Each reporting period	Projects must use the 100-year global warming potential derived from the IPCC Assessment Report stipulated in the latest version of the Reserve Offset Program Manual, which at the time of release of this protocol was the Fourth Assessment Report. Reproduced in the project parameters spreadsheet available at http://www.climateactionreserve.org/how/protocols/soil-enrichment/

Eq. #, Box Reference	Parameter	Description	Data Unit	Calculated (c) Measured (m) Reference (r) Operating Records (o)	Measurement Frequency	Description
Equation 5.20Equation 5.25	$EF_{Ndirect}$	Emission factor for direct nitrous oxide emissions from N additions from synthetic fertilizers, organic amendments and crop residues	tN_2O-N/t N applied	r	Once	Emission factor applicable to N additions from mineral fertilizers, organic amendments and crop residues, and N mineralized from mineral soil as result of loss of soil carbon. Referenced from the default tables in the project parameters spreadsheet available at http://www.climateactionreserve.org/how/protocols/soil-enrichment/
Equation 5.21	$M_{SF,s,t}$	Mass of N containing synthetic fertilizer applied for stratum *s* in cultivation cycle *t*	kg fertilizer	o	Each reporting period	See Section 3.4.1.3 for data requirements.
Equation 5.21	NC_{SF}	N content of synthetic fertilizer applied	t N/t fertilizer	o	Each reporting period	Manufacturers' specifications or third-party test results shall be used whenever available. Otherwise, peer-reviewed published data may be used. Indicative ranges of values for fertilizer N content are provided in the project parameters spreadsheet at http://www.climateactionreserve.org/how/protocols/soil-enrichment/
Equation 5.21	$M_{OF,s,t}$	Mass of N containing organic fertilizer applied for stratum *s* in cultivation cycle *t*	t fertilizer	o	Each reporting period	See Section 3.4.1.3 for data requirements.
Equation 5.21	NC_{OF}	N content of baseline organic fertilizer applied	t N/t fertilizer	r	Once	Manufacturers' specifications or third-party test results shall be used whenever available. Otherwise, peer-reviewed published data may be used. Indicative ranges of values for fertilizer N content are provided in the project parameters spreadsheet at http://www.climateactionreserve.org/how/protocols/soil-enrichment/

Eq. #, Box Reference	Parameter	Description	Data Unit	Calculated (c) Measured (m) Reference (r) Operating Records (o)	Measurement Frequency	Description
Equation 5.21	$Frac_{GASF}$	Fraction of all synthetic N added to soils that volatilizes as NH_3 and NO_x		r	Once	Referenced from the default tables in the project parameters spreadsheet, available at http://www.climateactionreserve.org/how/protocols/soil-enrichment/
Equation 5.21	$Frac_{GASM}$	Fraction of all organic N added to soils that volatilizes as NH_3 and NO_x		r	Once	Referenced from the default tables in the project parameters spreadsheet, available at http://www.climateactionreserve.org/how/protocols/soil-enrichment/
Equation 5.21Equation 5.24	EF_{Nvolat}	Emission factor for nitrous oxide emissions from atmospheric deposition of N on soils and water surfaces	tN_2O-N /(tNH_3-N + NO_x-N volatilized)	r	Once	Referenced from the default tables in the project parameters spreadsheet, available at http://www.climateactionreserve.org/how/protocols/soil-enrichment/
Equation 5.21	$Frac_{LEACH}$	Fraction of N added (synthetic or organic) to soils that is lost through leaching and runoff, in regions where leaching and runoff occurs		r	Once	Referenced from the default tables in the project parameters spreadsheet, available at http://www.climateactionreserve.org/how/protocols/soil-enrichment/
Equation 5.21Equation 5.23	EF_{Nleach}	Emission factor for nitrous oxide emissions from leaching and runoff	tN_2O-N / tN leached and runoff	r	Each reporting period	Referenced from the default tables in the project parameters spreadsheet, available at http://www.climateactionreserve.org/how/protocols/soil-enrichment/
Equation 5.23	$EF_{N2O,md,l}$	Emission factor for nitrous oxide from manure and urine deposited on soils by livestock type	kg N_2O-N/kg N input	r	Each reporting period	The emission factor for nitrous oxide from manure and urine deposited on soils is determined based on livestock type. Referenced from the default tables in the project parameters spreadsheet, available at http://www.climateactionreserve.org/how/protocols/soil-enrichment/

Eq. #, Box Reference	Parameter	Description	Data Unit	Calculated (c) Measured (m) Reference (r) Operating Records (o)	Measurement Frequency	Description
Equation 5.23, Equation 5.24	Nex_l	Nitrogen excretion of livestock type	kg N deposited/(t livestock mass *x* day)	r	Each reporting period	Referenced for the project site state based on default tables in the project parameters spreadsheet available at http://www.climateactionreserve.org/how/protocols/soil-enrichment/
Equation 5.24	$Frac_{GASMD}$	Fraction of N in manure and urine deposited on soils by livestock type that volatilizes as NH_3 and NO_x		r	Each reporting period	Referenced from the default tables in the project parameters spreadsheet, available at http://www.climateactionreserve.org/how/protocols/soil-enrichment/
Equation 5.24	$Frac_{LEACHMD}$	Fraction of N in manure and urine deposited on soils that is lost through leaching and runoff, in regions where leaching and runoff occurs		r	Once	Referenced from the default tables in the project parameters spreadsheet, available at http://www.climateactionreserve.org/how/protocols/soil-enrichment/
Equation 5.25	$N_{content,g}$	Fraction of N in dry matter for species *g*	tN/t dm	r	Each reporting period	The fraction of N in dry matter is determined based on the crop type. Referenced from the default tables in the project parameters spreadsheet, available at http://www.climateactionreserve.org/how/protocols/soil-enrichment/
Equation 5.25	$MB_{g,s,t}$	Annual dry matter, including aboveground and below ground, of species *g* returned to soils for stratum *s* at time *t*	t dm	o	Each reporting period	See Section 3.4.1.3 for data requirements.
Equation 5.27	$EF_{c,N2O}$	Nitrous oxide emission factor for the burning of agricultural residue type *c*	g N_2O/kg dry matter burnt	r	Once	Referenced from the default tables in the project parameters spreadsheet, available at http://www.climateactionreserve.org/how/protocols/soil-enrichment/

Eq. #, Box Reference	Parameter	Description	Data Unit	Calculated (c) Measured (m) Reference (r) Operating Records (o)	Measurement Frequency	Description
Equation 5.29	$EF_{CO2,j}$	Emission factor for the type of fossil fuel *j* combusted	tCO_2e/gal	r	Each reporting period	Referenced from the project parameters spreadsheet available at: http://www.climateactionreserve.org/how/protocols/soil-enrichment/
Equation 5.29	$FFC_{j,s,t}$	Consumption of fossil fuel type *j* for stratum *s* in cultivation cycle *t*	gallons	o	Each reporting period	Fossil fuel consumption can be monitored, or the amount of fossil fuel combusted can be estimated using fuel efficiency of the vehicle and the appropriate unit of use for the selected fuel efficiency.
Equation 5.30Equation 5.32	$YR_{c,t}$	Project-specific yield ratio for crop *c* during cultivation cycle *t*	ratio	c	Each reporting period	See Section 5.5.2 for guidance.
Equation 5.30Equation 5.32	$YR_{bsl,c}$	Average yield ratio for crop *c* during the historical baseline period	ratio	c	Each reporting period	See Section 5.5.2 for guidance.
Equation 5.30	$A_{c,t}$	Area of fields growing crop *c* during cultivation cycle *t*	acres	o	Each reporting period	See Section 5.5.2 for guidance.
Equation 5.31	$APH_{c,t}$	Average APH reported by fields growing crop *c* during cultivation cycle *t*	Bu/ac	r	Each reporting period	See Section 5.5.2 for guidance.
Equation 5.31	$APH_{RA,c,t}$	Regional average APH for crop *c* during cultivation cycle *t*	Bu/ac	r	Each reporting period	See Section 5.5.2 for guidance.
Equation 5.32Equation 5.33	$APH_{c,hy}$	Average APH reported by fields growing crop *c* during cultivation cycle *hy* of the historical baseline period	Bu/ac	r	Each reporting period	See Section 5.5.2 for guidance.

Eq. #, Box Reference	Parameter	Description	Data Unit	Calculated (c) Measured (m) Reference (r) Operating Records (o)	Measurement Frequency	Description
Equation 5.32	$APH_{RA,c,hy}$	Regional average APH for crop *c* during cultivation cycle *hy* of the historical baseline period	Bu/ac	r	Each reporting period	See Section 5.5.2 for guidance.
Equation 5.33	$APH_{f,c,hy}$	APH for field *f* growing crop *c* during cultivation cycle *hy*	Bu/ac	r	Each reporting period	See Section 5.5.2 for guidance.
Equation 5.33	$A_{f,c,hy}$	Area of field *f* growing crop *c* during historical cultivation cycle *hy*	acres	o	Each reporting period	See Section 5.5.2 for guidance.

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 verified emission reduction reports to the Reserve for every reporting period.

7.1 Project Documentation

Project developers must provide the following documentation to the Reserve in order to list a soil enrichment project:

a) Project Submittal form
b) Project map (providing a general overview of where project fields are located, accurate at least to the county level; public)
c) Project map (detailed spatial file in .KML format with precise location of participating fields; not public)

Project developers must provide the following documentation each reporting period in order for the Reserve to issue CRTs for quantified GHG reductions:

- Project maps (updated general overview map and .KML file, if changed from listing and/or previous reporting period)
- Signed Attestation of Title form
- Signed Attestation of Voluntary Implementation form
- Signed Attestation of Regulatory Compliance form
- Monitoring plan (initial reporting period)
- Monitoring report (all reporting periods)
- Contract(s) for ownership of emission reductions (where applicable)

Verifiers will provide a verification report, list of findings, and verification statement. The Reserve will coordinate executing of a Project Implementation Agreement during the initial reporting period, and Project Implementation Agreement Amendments during subsequent reporting periods. At a minimum, the above project documentation (except for the detailed project map) 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 developers may seek Reserve approval for redacting sensitive business information contained in any documents that are to be posted publicly. Project submittal forms can be found at http://www.climateactionreserve.org/how/program/documents/.

7.2 Defining the Reporting Period

The reporting period is the period of time over which GHG emission reductions from project activities are quantified. The typical reporting period under this protocol is one complete cultivation cycle (variable *t* in equations detailed in Section 5). The cultivation cycle may be defined differently for annual crops, perennial crops, and perennial pasture, but should align with the end of one growing season and the beginning of another. For the purposes of this protocol, a cultivation cycle is generally defined as the period between the first day after harvest of the last crop on a field and the last day of harvest of the last crop on a field during the reporting period (Figure 7.1). However, this definition will be adjusted in several different scenarios.

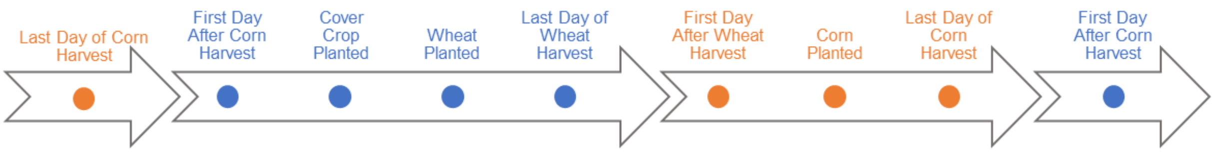
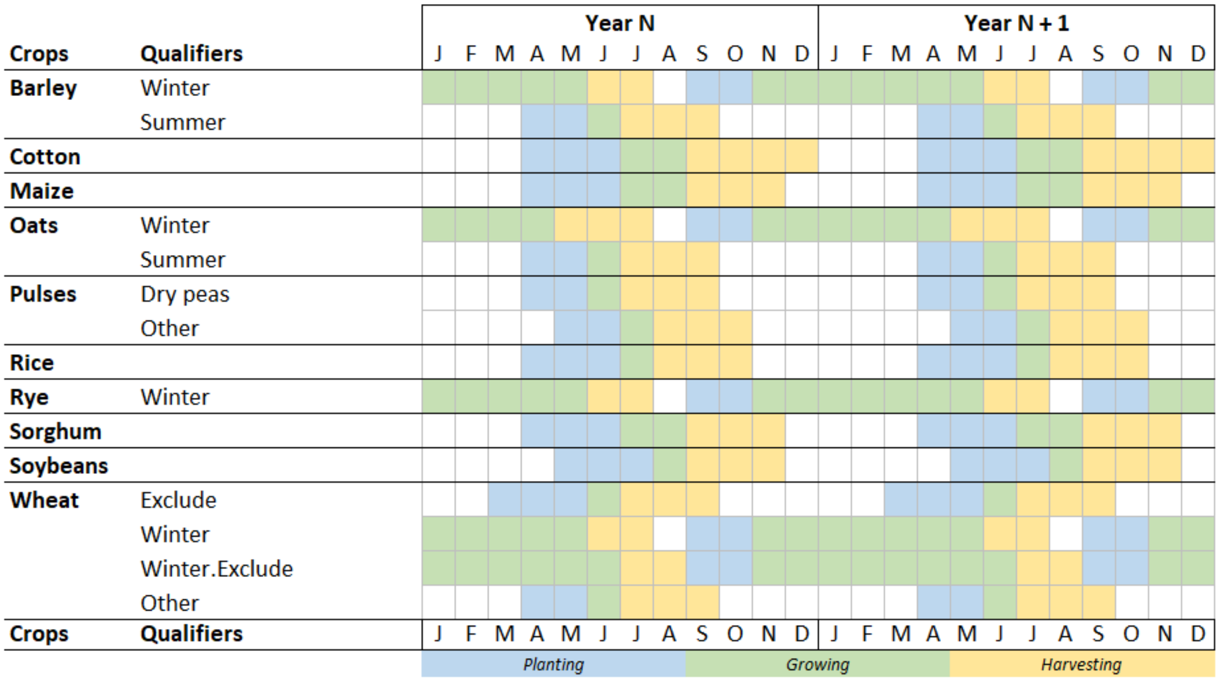


Figure 7.1. Example of Typical Cultivation Cycles

For fields with perennial cropping systems (including grazing), or systems where there is not a clear harvest event between seasons (e.g., cash crop seeded directly into a living cover crop), the project developer shall document and/or justify the date chosen to represent the end of one growing season and the beginning of the another (e.g., planting date). Figure 7.2 below, illustrates the variability in agronomic cycles for various crops throughout the year, demonstrating why flexibility is required for soil enrichment projects.

- A cultivation cycle may be greater or less than a calendar year, and may include multiple growing seasons, including cash crops, cover crops, and pasture
- For perennial crops with one or more harvests during a growing season, the last harvest will generally define the cultivation cycle
- For perennial crops without harvests or perennial pasture systems, the cultivation cycle may be defined by the project developer in a way intended to align with the annual cycle of growth on the field
- For cultivation cycles which begin following a period of pasture, the cultivation cycle may begin with field preparation for crop production
- Where inter-seeding is practiced (through companion cropping, relay cropping, planting cash crops into live cover crops, or planting cover crops into live cash crops), the cultivation cycle may be defined by the project developer
- The length of the cultivation cycle may vary from year to year, depending on weather and the overall crop and management rotation schedule



Based on average planting start/end dates and average harvest start/end dates in the United States (2018)

https://nelson.wisc.edu/sage/data-and-models/crop-calendar-dataset/index.php

Figure 7.2. Illustration of the Range of Dates for Various Crops in the U.S.

When a project comprises multiple eligible crop fields, the reporting period in a given year starts on the earliest date that a field being submitted for credits begins its eligible cultivation cycle, and the reporting period ends on the latest date that a field being submitted for credits ends its cultivation cycle. This will mean that a project may experience overlapping reporting periods (Figure 7.3), i.e., a reporting period may end in November of a given year, but if a winter crop is grown on a field submitted to the project for crediting in the next cultivation cycle, the subsequent project reporting period may actually begin that same November, potentially prior to the end of the last reporting period.

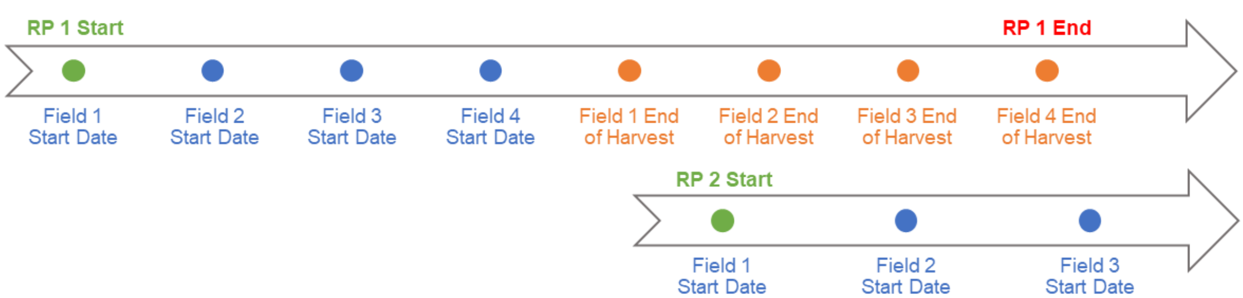


Figure 7.3. Example of Overlapping Reporting Periods for a Project with Multiple Eligible Crop Fields

Despite this, there will be no risk of double issuance of emission reductions, for several reasons:

- Quantification of emission reductions occurs on a field by field basis, based on the cultivation cycle of the given field
- Fields can only be registered to one project at any given point in time, therefore fields can only have emission reductions issued to one project for any given reporting period
- Field reporting periods cannot overlap, because they are defined by the field's cultivation cycle. The new cultivation cycle will only start once the previous crop harvest *on that field* has concluded

Although reporting periods will typically comprise only one cultivation cycle, the initial reporting period for the project as a whole or any given field(s) may comprise either one or two cultivation cycles.

7.3 Reporting Period and Verification Cycle

Project developers must report GHG reductions resulting from project activities during each reporting period. The verification period is the period of time over which project reporting is verified and credits are issued. An individual verification period may comprise no more than five (5) reporting periods. Projects may submit for verification for up to 5 reporting periods at a time, and verification for each field may include up to 5 reporting periods for the given field. If a field is unable to get into the project verification process by the Reporting Deadline for its initial Reporting Period, but the overall Project does undergo verification, the field may be included in the subsequent verification cycle. In the event of an avoidable reversal, the verification period may be required to be shortened to fulfill the compensation requirements specified in Section 5.3.2.1. To meet the verification deadline, the project developer must have the required project documentation (see Section 7.1) submitted as soon after the end of each reporting period as possible, as verifiers have 12 months following the end of the reporting period to review the project documentation and submit the verification report and statement. For reporting periods for which the project developer is deferring verification to a future date, a monitoring report must be submitted prior to the required verification deadlines (i.e., 12 months following the end of the reporting period).

7.4 Reporting for Aggregated Projects

Projects which aggregate multiple fields and/or Field Managers are not subject to different reporting requirements from projects which comprise only a single field or Field Manager. As described above, aggregated projects will likely result in overlapping reporting periods at the project level. While the emission reductions are quantified for the project as a whole, the data collection and documentation must be conducted at the field level.

7.5 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. If projects wish to measure initial SOC samples below 30 cm with the hope of being able to be credited for SOC gains below 30 cm at some point in the future, such data and the verification of such data must be retained until the time when resulting emission reductions can be effectively modeled, but the soil samples themselves need not be retained (as described in Section 6.5.1).

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 the project emission reductions, including all required sampled data, as well as the results of emission reduction and sequestration calculations
- All modeling outputs (if applicable)
- Copies of all permits, Notices of Violations (NOVs), and any relevant administrative or legal 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
- All verification records and results
- All maintenance records relevant to the monitoring equipment

7.6 Reporting and Verification of Permanence

When the final crediting period for a SEP project ends, the project enters the permanence period. Per Section 3.5, unless the Reserve has approved an alternative mechanism for insuring permanence, 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) (unless tonne-year accounting was employed for determining credit issuance). 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 capabilities of the Project Owner, as well as the approval of any alternative mechanisms by the Reserve. 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 at least every five years. The required periodic monitoring reports shall, at a minimum, contain the following:

- Evidence to support the conclusion that no reversals have occurred on the project area since the previous reported time period; and,
- Information related to ongoing activities on the site.

In certain cases (see Section 7.6.3) 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 5.3.2 regarding compensation for reversals shall apply.

7.6.1 Scope of Monitoring for Permanence

Given that the permanence period is focused only on protection of the soil organic carbon for which credits have been issued, the scope of monitoring is narrower than during the crediting period. When monitoring for permanence, the Project Owner must consider the following sources of reversal risk:

Table 7.1. Sources of Reversal Risk Monitored During the Permanence Period

Sources of Reversal Risk	Examples	Monitoring Parameters
Wholesale change to an incompatible land use	▪ Land conversion to development	▪ Introduction of persistent, non-vegetated areas
Physical disturbance of the soil within the project area	▪ Sustained increase in tillage frequency ▪ Localized disturbance for development (e.g., wind turbines, roads, farm buildings)	▪ Tillage events ▪ Introduction of persistent, non-vegetated areas
Unavoidable reversals	▪ Catastrophic flooding which erodes away the soil surface ▪ Prolonged drought leading to significant decline in vegetative productivity and photosynthetic activity	▪ Appearance of persistent, non-vegetated areas following detection of a flooding event ▪ Significant decline in estimated plant productivity over multiple years
Overgrazing	▪ Grazing not in line with grazing management plan	▪ Animal Grazing Days (*AGD)*, total number of days grazed per animal category (see Equation 5.11 and Box 5.3 for further guidance)

During the permanence period, any field employing grazing must employ a mechanism to detect and prevent overgrazing on project lands, which is tailored to the specific conditions of their project and its ecosystem. It is up to each project developer to determine the appropriate means to safeguard the project against overgrazing.

Project Owners must provide both a quantitative and qualitative accounting of grazing activities for the duration of the permanence period, so long as grazing is being employed. In terms of quantitative data, projects must document the type of livestock being grazed and the total animal grazing days for each type (Box 5.3). The livestock shall be categorized according to the categories in the *SEP Parameters* spreadsheet.[27] The frequency of monitoring and the form of the documentation is not prescribed by this protocol. In terms of qualitative reporting, project developers shall include in their monitoring report a description of grazing activity for the duration of the permanence period, so long as grazing is employed, and whether this conforms to the administrative mechanism (as described above) in place to guard against overgrazing. Written confirmation from the entity or entities providing oversight with respect to this administrative mechanism should be provided to the Reserve that no overgrazing has occurred during the permanence period, and also to the verifier, if fields employing grazing have entered their permanence period, whilst other parts of the project are still within their crediting period.

The verifier shall use professional judgment to confirm with reasonable assurance that the quantification of project emissions from grazing is conservative, that effective monitoring of grazing has been maintained in accordance with this administrative overgrazing mechanism, and that no overgrazing has been detected using this administrative mechanism.

[27] Available at: http://www.climateactionreserve.org/how/protocols/soil-enrichment/.

Examples of documentation that may suffice to demonstrate the quantitative grazing monitoring requirements may include (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

In addition, the Reserve may conduct additional review to confirm that a reversal has not occurred due to overgrazing.

The project developer must obtain Reserve approval for the particular administrative means they will use to ensure project land is not overgrazed. Such approval (and approval for any subsequent changes to the mechanism) must be obtained prior to registration of any reporting period during which grazing was employed. The mechanism in question should include requirements for monitoring and enforcement, as well as identify the entity or entities that are responsible for such enforcement. The entity empowered to enforce this mechanism must be an entity (or entities) other than the Reserve, and can be a third-party to the offset project (e.g., an easement holder, a landlord etc.). Project developers shall include in their monitoring plan full details of the administrative mechanism they are employing to safeguard against over-grazing.

In terms of qualitative reporting, project developers shall include in their monitoring report a description of grazing activity for the reporting period. Written confirmation from the entity or entities providing oversight with respect to this administrative mechanism should be provided to the verifier that no overgrazing has occurred during the verification period. The verifier shall use professional judgment to confirm with reasonable assurance that the quantification of project emissions from grazing is conservative, that effective monitoring of grazing has been maintained in accordance with this administrative overgrazing mechanism, and that no overgrazing has been detected using this administrative mechanism.

7.6.2 Use of Remote Methods for Detecting Reversals

The project developer may elect to continue monitoring the project area according to the approaches undertaken during the crediting period (according to the scope outlined in Section 7.6.1) using the relevant monitoring guidance of Section 6. However, it is anticipated that remote monitoring will be employed during the permanence period as a matter of standard practice, regardless of how much it was used during the crediting period. This protocol allows for remote monitoring of permanence so long as the project developer can demonstrate that the methods used are capable of detecting the events and changes described in Section 7.6.1 with reasonable certainty.

7.6.3 Verification During the Permanence Period

If some portion of the project is still actively reporting under its crediting period, then any portion of the project which has entered the permanence period and is subject to the monitoring described in Sections 7.6.1 and 7.6.2 shall continue reporting on the same timeframe as the overall project. In this case, the project's monitoring plan shall contain information regarding fields which have entered their permanence period and the monitoring which has been conducted during the relevant reporting period.

If the entire project has entered the permanence period, unless the project developer has received approval from the Reserve for an alternative mechanism for ensuring permanence, which shall take precedent over this paragraph, monitoring reports must be verified at least every five years during the permanence period. Such verification shall consist only of a desk review of the monitoring report and the evidence collected to support its conclusions. Verifiers may conduct a risk-based sampling of fields for deep scrutiny according to the guidance in Section 8.

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 soil enrichment projects.

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

- Reserve Offset Program Manual
- Climate Action Reserve Verification Program Manual
- Climate Action Reserve Soil Enrichment Protocol (this document)
- Any applicable policy memos and errata and clarifications

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

Only ISO-accredited verification bodies trained by the Reserve for this project type are eligible to verify soil enrichment projects. Verification bodies approved under other protocol types are not permitted to verify soil enrichment projects. Information about verification body accreditation and Reserve project verification training can be found on the Reserve website at http://www.climateactionreserve.org/how/verification/.

8.1 Standard of Verification

The Reserve's standard of verification for soil enrichment projects is the Soil Enrichment Protocol (this document), the Reserve Offset Program Manual, and the Verification Program Manual. To verify a soil enrichment 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 Table 6.4 are collected and recorded.

8.3 Core Verification Activities

The Soil Enrichment Protocol provides explicit requirements and guidance for quantifying the GHG reductions associated with the soil enrichment project. 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 soil enrichment 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 of 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 soil enrichment project operator uses to gather data and 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 field (or fields if the project includes multiple fields) 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.

8.3.1 Verifying Proper Use of Models

Guidance for the verification of the proper use of models is contained in the *Model Requirements and Guidance* document.[28]

Each verification team must demonstrate, to the Reserve's satisfaction, that they include a team member in each given reporting period that is sufficiently knowledgeable regarding the use of the particular model used to quantify emission reductions in that reporting period (if any). Verifiers will be required to confirm the requirements in the *Model Requirements and Guidance* document are met. Verifiers are not expected to review and confirm the successful validation of the model, as this step already requires independent review and assessment, separate from the project verification. Rather, the verifier must assess and confirm whether the validation report referenced for the use of models during the reporting period is, in fact, appropriate to the project domain. This includes assessing appropriate coverage of the crop types, practices, and climate zones, for example.

If the project employs the use of a third-party expert to undertake validation, parameterization, calibration, and/or running a biogeochemical model in a given reporting period, then there will be no need for the verification team to include an expert in the use of such model or to independently verify such activities have been done appropriately, provided the verification team: that the party in question has the requisite expertise, that all requisite steps as set out in

[28] Available for download at: https://www.climateactionreserve.org/protocols/soil-enrichment. Ensure that you are referring to the most current version of this guidance document.

the *Model Requirements and Guidance* document have been followed, and provided the expert provides the verification team with a sensitivity analysis regarding the requisite data inputs for the given model.

In other words, the verifier is simply required to confirm approval from the Reserve, confirm the qualification of the third-party, and confirm the requisite validation steps have been followed, but the verifier does not independently need to run the model themselves to confirm results appear reasonable. The verification team will still be required to confirm the reasonableness of all data input into the given biogeochemical model, following the requirements for baseline modeling in Section 3.4.1.3, and following expert guidance on the sensitivity of the given model to the requisite data inputs.

8.3.2 Verification of Soil Samples

Verifiers must confirm that the requirements detailed in Section 6.5 are carried out appropriately. The Project Owner must demonstrate that the sampling requirements were followed (including separation of samples into depth portions, if applicable, as specified in Section 6.5.1), and must provide digital records of the sample locations (e.g., GPS logs, geotagged photos etc.).

Whether and to what degree a verifier employs resampling on any given field will be left to the discretion of the verifier, based on their professional judgement. When resampling is conducted as part of the verification, the verifier may either conduct the sampling themselves, or use a sampling technician, provided any such sampling technician is appropriately qualified and is not affiliated with the Project Owner. Instead of re-sampling a plot that was previously sampled by the project, the verifier may, in their professional discretion, look at the soil profile of several random plots and profiles from non-plot areas, to determine if there are differences in A horizon thickness, or other evidence of added materials.

Similarly, the lab analysis procedures must be demonstrated to have been followed. During site visits, verifiers may request a demonstration of the soil sample collection procedure.

8.4 Verification of Projects

Guidelines for verification sampling and verification schedules are the same for individual projects (single Field Manager with multiple fields) and aggregated projects (multiple Field Managers and/or multiple fields). This approach allows a consistent application of verification requirements at the project level, regardless of size or number of fields in the project, or whether the projects are combined into an aggregate or not.

There are three levels of verification which a project goes through each reporting period. Every reporting period the GHG assertions made for the entire project will be subject to verification, with assessment of the process by which quantification is conducted at the sample unit and subsequently aggregated to the project level. Every reporting period a subset of Field Managers in a given project (a minimum of ½ of the square root of all Field Managers in the project) will be subjected to a site visit verification. Every reporting period a subset of Field Managers (a minimum of ½ of the square root of all Field Managers in the project, not being those Field Managers selected for a site visit verification for that given reporting period) will be chosen for a desktop verification. Note that for all projects a minimum of 2.5% of all Field Managers in the project will be subjected to a verification in every reporting period.

The verifier shall consider which Field Managers have not been selected in the past for either a site visit or desktop verification, meaning those Field Managers who have not yet been selected shall have a higher probability of selection with each subsequent verification event, but all Field Managers will have a nonzero probability of selection during any given round of verification services. In all cases, the verification schedule shall be established by the verification body using a combination of risk-based and random sampling, according to the verification schedule and sampling methodologies outlined in Section 8.4.1. These sampling methodologies establish a minimum, and possible range, of site visit frequencies, as well as guidance on circumstances in which the verification body is encouraged to add fields beyond the minimum number of fields required for site visit and/or desktop verification. The verifier may use professional judgment to determine the number of additional fields and method for selecting fields if a risk-based review indicates a high probability of non-compliance. The verification minimum sampling requirements are mandatory regardless of the mix of entry dates represented by the group of fields in the project (and by the group of growers in the grouped project).

The initial site visit verification schedule for a given year shall be established after the completion of the NOVA/COI process. The schedule should be established as soon as possible after the commencement of verification activities, at a minimum, so as to include both risk-based and random sampling for the selection of site visited fields. This is meant to allow for the project developer and verification body to work together to develop a cost effective and efficient site visit schedule. Specifically, once the sample fields designated for a site visit have been determined, the verification body shall document all fields selected for planned site visit verification and provide a list of fields receiving a visit to the project developer and the Reserve[29]. The project developer shall be responsible for all site visit planning. Following this notification, the project developer shall supply the verification body with all the required documentation to demonstrate field-level conformance to the protocol. When a verification body determines that additional sampling is necessary due to suspected non-compliance, however, a similar level of advance notice may not be possible.

Though significant advance notice of a field’s selection for a site visit is required, project developers shall not be given advanced notice of which fields’ data will be subject to desktop verification in a given year. A field shall be prepared for desktop verification during every verification period, so long as the field’s Monitoring Plan is implemented and up to date, the Field Report submitted to the project developer, and all recordkeeping requirements of this protocol are followed.

Regardless of the size of a project, if the project contains any fields that did not pass site visit verification the year before and wish to re-enter the project, those fields must have a full verification with site visit for the subsequent reporting period. These fields must be site visited in addition to the verification sampling methodology and requirements outlined below in Section 8.4.1. In all cases, when determining the sample size for site visits and desktop verifications, the verification body shall round up to the nearest whole number. The documentation requirements for performing a site visit verification and desktop verification are the same. A desktop verification is equivalent to a full verification, without the requirement to visit the site. A verification body has the discretion to visit any site in any verification period if the verification body determines that the risks for that field warrant a site visit.

[29] If the Reserve has indicated staff will be performing oversight on the verification activities, this list must be provided as soon as it is available. If Reserve staff are not performing oversight on the verification activities, this list must be provided with the submittal of the verification report.

8.4.1 Verification Site Visit Requirements

This protocol requires verifiers use a combination of risk-based and random sampling to select fields for site visits. The sampling methodology for projects shall take place in three steps:

1. Site visit verifications selected via field manager-level risk assessment: Verifiers shall select field managers for site visits first through a risk-based approach. The verifiers' risk evaluation may presume higher risk exists for field managers with higher acreage that contribute more to the emission reductions, field managers that implement a novel practice change, field managers that have recently implemented a new practice change from prior reporting periods, or have exhibited challenges during past verifications, etc. A number of field managers representing a minimum of one-half the square root of field managers in the project must be visited. If selection of higher risk field managers does not meet this threshold, verifiers proceed to step 2 to select additional field managers via random sampling.
2. Additional site visit verifications selected via random sampling: Once the verifier has selected field managers for site visits through the risk-based approach, additional field managers shall be selected at random. The verification body shall randomly select additional field managers until the number of site visits meets a minimum threshold of at least one half the square root of the total number of field managers in the project (or a higher number chosen by the verifier, if appropriate, based on higher project-level risk – see further description below).
3. Desktop verifications selected via random sampling: Verification bodies shall randomly select a sample of field managers to undergo a desktop verification equal to 1/2 the square root of the total number of field managers in the project (rounded up to the next whole number). Field managers selected for site visit verifications based on steps 1 and 2 shall not be eligible for selection for desktop verification during that year.

The verification body shall be allowed to increase the number of site visits performed above the minimums described above based on levels of perceived project-level risk identified during verification. Specific risks identified during the verification could include field managers generating large proportions of the emission reductions of the project, lack of historical records, and/or demonstrated poor communication of project activities and implementation between field managers and project developers. If the verifiers and project developer disagree on the number of field managers to be visited, they should contact the Reserve. Each verification report must contain a description of the sampling methodology, number of field managers visited, and justification for higher levels of sampling (e.g., due to higher levels of risk). Once field managers have been selected for site visits, verifiers will use their discretion to determine the number of fields under management by the field managers that they will visit or study via other means.

Once field managers (and the fields they manage) have been selected for site visits, verifiers may seek Reserve approval to forgo an actual site visit, if sufficient proxy data exists such that a verifier considers it unnecessary for a member of the verification team to physically visit the relevant field(s) themselves. Examples of proxy data that may satisfy a verifier in this regard include where the project developer has engaged an independent third-party with agronomic expertise (such as local NRCS staff and/or local University extension service staff) to instead undertake a site visit. A verifier might have a third-party complete a signed statement attesting that the things a verifier considered highest risk and for which a site visit would be most useful, have been confirmed by that third-party. A verifier may propose to undertake a remote site visit, whereby a party walks the ground and provides live video feed to the verifier. In assessing a request for a remote site visit, the Reserve will take into consideration guidance prepared by the

ANSI National Accreditation Board (ANAB) on the use of remote site visit verifications, as well as any guidance forthcoming on the use of remote site visit verifications prepared by any other offset registry or program, and any guidance the Reserve itself develops for such activities.

All parties should be on notice that Reserve approval will be needed for each field managers for which the verifier proposes to not physically visit their field themselves, and that granting of such approval is by no means guaranteed, and does not serve as precedent for future reporting periods. Verifiers should seek Reserve approval as early as possible in order to determine if such approval is likely in any given circumstances.

8.5 Soil Enrichment Verification Items

The following tables provide lists of items that a verification body needs to address while verifying a soil enrichment project. The tables include references to the section in the protocol where requirements are further specified. The tables also identify 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 soil enrichment projects that must be addressed during verification.

8.5.1 Project Eligibility and CRT Issuance

Table 8.1 lists the criteria for reasonable assurance with respect to eligibility and CRT issuance for soil enrichment 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 8.1. Eligibility Verification Items

Protocol Section	Eligibility Qualification Item	Apply Professional Judgment?
2.2	Verify that the project meets the definition of a soil enrichment project a. Evidence provided indicating project was cropland or grassland at the project start date; b. Project does not involve a material decrease in woody perennials within the project area; c. Field boundaries are clearly delineated and identify discrete and continuous areas (fields) in which the same crop (or crop mix) is grown during the reporting period	Yes
2.2.2	Verify fields adhere to the various requirements set out in Section 2.2.2	No
2.2.2	Verify that projects have appropriately screened for HEL and wetlands, and that any fields found to be HEL or wetlands have demonstrated USDA certification.	No

Protocol Section	Eligibility Qualification Item	Apply Professional Judgment?
2.2.3.1 2.2.3.2	Verify all fields participating in an aggregated project have been added appropriately to the project. All fields in projects receiving transferred fields must satisfy all eligibility requirements of the newest protocol version in use amongst all fields prior to transfer	No
2.3	Verify ownership of the reductions by reviewing Attestation of Title, and where relevant, contracts between growers and Project Owner. As needed, inquire as to potential double-counting of credits issued under another protocol (internal or external to the Reserve) for activities that have possible overlap with activities credited under this protocol (e.g., biochar application)	No
2.4	Description provided outlining how project does not undermine progress on other environmental issues (e.g., air and water quality, endangered species and natural resource protection, environmental justice)	No
3.2	Verify accuracy of project and field start dates based on operational records	Yes
3.2	Verify that the project has documented and implemented a Monitoring Plan	No
0	Verify each field seeking credits in a given reporting period is within its 10-year crediting period. Verify the project has approval from the Reserve for any renewed 10-year crediting periods	No
3.4.1	Verify that the project meets the performance standard test. Description of practice change being implemented on each participating field provided in Monitoring Plan, with indication that GHG impacts of each practice change can be modeled	Yes
3.4.1.5	Verify description of baseline data sources and how such data were converted into model inputs is provided. Verify qualitative data were determined in consultation with Field Manager of relevant field(s), who has provided a signed attestation confirming such data is correct. Verify quantitative data used are consistent with hierarchy of priority	No
3.4.2	Confirm no laws are in force that mandate the project activities. Confirm the Attestation of Voluntary Implementation has been appropriately executed	No
3.4.2	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
3.4.3	Verify the project is not simultaneously receiving credits or payments for the same project activities, in contravention of requirements of Section 3.4.3	No
3.5	Verify which option the project has chosen to use to meet the permanence requirements, and verify any evidence as applicable (optional application of TYA has been calculated appropriately, permanence period is identified in the PIA, PIA is appropriately executed, or use of alternative mechanisms has been approved by 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 developer, by undertaking independent investigations to confirm if any violations exist, and by 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 a variance has been approved for monitoring variations	No
6.1	Verify that the selection of baseline data source followed the prescribed hierarchy, that the data inputs appear reasonable, and that any requisite Reserve approval has been obtained	Yes

8.5.2 Quantification

Table 8.2 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 8.2. Quantification Verification Items

Protocol Section	Quantification Item	Apply Professional Judgment?
4	Verify that all SSRs in the GHG Assessment Boundary are accounted for	No
3.4.1.3 5.1	Verify that the baseline emissions are properly aggregated	No
5 6.5	Verify that quantification approach for each GHG and GHG source is identified (see Table 5.2) and is applied consistently across baseline and project scenarios. Verify quantification is based on updates to SOC measurements that occur at a frequency of no less than every five years	Yes
5	Verify that the project emissions were calculated according to the protocol with the appropriate data	Yes
5	Verify that the project developer correctly monitored, quantified, and aggregated fossil fuel use	Yes
5	If default emission factors are not used, verify that project-specific emission factors are based on official source-tested emissions data or are from an accredited source test service provider or Reserve approval has been granted for their use	No
5.2	Verify that the uncertainty deduction is calculated correctly per Equation 5.1 and Appendix D	No
5.3	Verify the correct version of Equation 5.2 is used to calculate reversible emission reductions, based on permanence mechanism employed by the Project Owner	No
5.3	Verify Equation 5.3 is correctly applied, using measurement and/or modeling results for SOC and for the current reporting period, as well as the current uncertainty deduction	No
5.3.1	Verify buffer pool contribution is calculated correctly, using the proper value for $Risk_{rev,rp}$, which is substantiated, as needed, with a demonstration that: - <50% of the project's acreage is in a single LRR - The Project Owner meets the requirements for reducing the risk of financial failure to 0	No
5.3.2	Verify that if net loss of SOC for the reporting period has been reported (negative result from Equation 5.3), the reversal amount has been calculated correctly using Equation 5.5	No
5.3.2.1 5.3.2.2	Verify that if a reversal has occurred, the Project Owner has followed the notification procedures outlined in Section 5.3.2.1 or Section 5.3.2.2	No
5.4.1	Verify that AGD calculated correctly following guidance in Box 5.3	No
5.4.1	Verify that correct version of Equation 5.11 and Equation 5.13 are used, depending on whether models or default equations are used. Ensure appropriate EFs are used (from *SEP Parameters* file) or model results are input correctly	No
5.4.3	Verify whether fossil fuel usage is likely to have increased more than 5% due to project, and whether any means for estimating fossil fuel usage is reasonable, conservative, and applied appropriately	Yes
5.5.1	Verify leakage with respect to livestock has been assessed and, where relevant, appropriately accounted for	No
5.5.2	Verify APH assessment done appropriately and, where relevant, crop leakage accounted for appropriately	No
6.5	Verify that stratification and sampling requirements as set out in Section 6.5 were appropriately followed – see Section 8.5.4 for more information on verification of direct measurements. Confirm persons undertaking soil sampling have sufficient knowledge to do so	Yes

Protocol Section	Quantification Item	Apply Professional Judgment?
6.6	Verify that the given biogeochemical model used to model baseline emissions, and optionally reporting period emissions, meets the requirements of this protocol	No
6.6	Verify that the given biogeochemical model used to model baseline emissions, and optionally reporting period emissions, has been properly validated	Yes
6.1, 6.6	Verify that all biogeochemical model inputs are reasonable, taking into account the baseline evidence hierarchy in Section 6.1, and guidance provided by an expert in the use of the given biogeochemical model	Yes

8.5.3 Monitoring and Reporting

Verification bodies will review the following items in Table 8.3 to guide and prioritize their assessment of data used in determining eligibility and quantifying GHG emission reductions.

Table 8.3. Monitoring and Reporting Verification Items

Protocol Section	Monitoring and Reporting Item	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 the individual or team responsible for managing and reporting project activities are qualified to perform this function	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
6.3	Verify monitoring is sufficient to demonstrate type/number of animals grazing on project. Ensure monitoring sufficient to demonstrate appropriate administrative mechanism to guard against overgrazing	No
6.6	Verify that soil sampling has been performed at least every five years	No
6.5.1	Verify that soil sampling and lab analysis meets min protocol requirements, as set out in Table 6.2. Confirm persons undertaking soil sampling have sufficient knowledge to do so	Yes
6.5.2	Verify soil sampling and lab analysis meets min protocol requirements, as set out in Table 6.2. Confirm lab undertaking analysis has demonstrated proficiency through NAPTP program	No
6.7	Verify model meets minimum requirements. Review sensitivity analysis on model inputs from model experts. Confirm model inputs are reasonable. Confirm that requirements in *Model Requirements and Guidance* document have been met. Confirm use of third-party modeling expert has been approved by Reserve (where relevant), and that the qualifications for the expert presented to the Reserve are reasonable	Yes
6.7	Verify parameters used in quantification meet requirements set out in Table 6.3	No
7.2	Verify the project reporting period aligns with the cultivation cycle(s)	No
7.5	Verify that all required records have been retained by the project developer	No

8.5.4 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, or employee thereof, approved by the Climate Action Reserve to provide verification services for project developers.
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 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.
Cropland	Arable and tillage land and agro-forestry systems where vegetation falls below the threshold used for the forest land category (>10% canopy cover).
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).
Field Manager	The entity with operational control of agricultural management decisions for a given field(s) in the project area during the relevant reporting period.
Fossil fuel	A fuel, such as coal, oil, and natural gas, produced by the decomposition of ancient (fossilized) plants and animals.
Grassland	Areas dominated by grasses with <10% tree canopy cover, including savannas (i.e., grasslands with scattered trees). Grasslands also include managed rangeland and pastureland that is not considered cropland where the primary land use is grazing, and which may also include grass-dominated systems managed for conservation or recreational purposes.
Greenhouse gas (GHG)	Carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), sulfur hexafluoride (SF_6), hydrofluorocarbons (HFCs), or perfluorocarbons (PFCs).
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.
Highly Erodible Land (HEL)	Land with Highly Erodible Soils are those that have a potential to erode at a rate far greater than what is considered tolerable soil loss.
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 2204.6 pounds or 1.1 short tons.
Methane (CH_4)	A potent GHG, 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.).
N-fixing species	Any plant species that associates with nitrogen-fixing microbes found within nodules formed on the roots, including but not limited to soybeans, alfalfa, and peas.
Organic nitrogen fertilizer	Any organic material containing N, including but not limited to animal manure, compost and biosolids. Fertilizers are considered organic if derived from plant and animal parts or residues.
Professional agronomist	Any individual with specialized knowledge, skill, education, experience, or training in crop and/or soil science.
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 GHG project, as identified in Section 2.2 of this protocol.
Sample point	Sample location of undefined area.
Sample unit	Defined area that is selected for measurement and monitoring, such as a field.
Synthetic nitrogen fertilizer	Any synthetic fertilizer (solid, liquid, gaseous) containing nitrogen (N). This may be a single nutrient fertilizer product (only including N), or any other synthetic fertilizer containing N, such as multi–nutrient fertilizers (e.g., N–P–K fertilizers) and 'enhanced–efficiency' N fertilizers (e.g., slow release, controlled release and stabilized N fertilizers). Fertilizers are considered synthetic if derived from inorganic compounds, which are in turn usually derived from by-products of the petroleum industry.
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.

Woody perennials	Trees and shrubs having a lifecycle lasting more than two years, not including cultivated annual species with lignified tissues, such as cotton or hemp.

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Appendix A Development of the Performance Standard

This protocol uses a two-stage *common practice* additionality assessment. The first stage involves the application of a *negative list* of specific activities, in specific parts of the country, which are deemed to be non-additional by default. The second stage allows projects to use project-specific measures to demonstrate any parts of a project identified as being non-additional by default according to the *negative list* to be deemed additional. This *negative list* was developed using uptake rates of the given practices, in counties around the U.S. An extensive analysis of barriers to adoption of the various eligible practices, as well as other factors, was used to inform development of uptake rate thresholds and also to inform development of the second stage project-specific measures to demonstrate additionality, for any parts of a project identified as being on the *negative list*.

This appendix first sets out a barriers analysis, and then sets out the analysis undertaken in development of the two-stage common practice assessment. This appendix is set out as follows:

- Introduction to Development of the Barriers Analysis Component of the Performance Standard
    - Non-Financial Barriers to Adoption of Soil Enrichment Practices
    - Farmer Decision Making Under High Uncertainty and High Risk
    - Trends in Adoption of Soil Enrichment Practices
    - Discrete Change and Practice Adoption Over Time
- Development of the Common Practice Assessment

A.1 Introduction to Development of the Barriers Analysis Component of the Performance Standard

Given the incredible diversity of practice change scenarios, the myriad variables involved in both farmer decision-making and the estimation of GHG impacts of management practice changes, and a lack of comprehensive data on uptake of such practices, it would be impossible to develop a comprehensive *positive list* of individual, quantitative performance thresholds based on specific practices. The goal of this protocol – to incentivize multiple practice adoption over time – means that such complex approaches to additionality would be unworkable. Moreover, farmers will not participate in the program with such rigid and complex requirements for entry. Thus, a simplified approach has been adopted, supported by the rationale in this appendix.

The thesis for this approach is summarized as follows:

- Farmers are risk-averse;
- Farmers are motivated by multiple factors, attempting to maximize utility in multiple ways, rather than simply focusing on long-term profit maximization;
- While some practices have seen some measure of adoption in some regions and cropping systems, the overall experience is mixed, without a clear trend towards increasing adoption of soil enrichment practices;
- This protocol goes beyond business-as-usual by ensuring growers receive incentives (carbon credits) only when they adopt practice change, demonstrate measurable GHG impacts of such practice change, and ensure that increases in soil carbon provide atmospheric benefits equivalent to storage maintained for 100 years.

Multiple parties within society are faced by similar broad pressures as those faced by farmers, and multiple parties similarly are thus motivated to pursue utility maximization in a sense broader than a mere focus on economic outcomes. However, individual motivations are rarely directly entwined with the decisions of a commercial enterprise as they are in farming. It is contended that for this thesis to effectively demonstrate additionality, it is not necessary to demonstrate that farmers (as individuals) face greater pressures for a broader approach to utility maximization than those faced by other parts of society. It is enough to demonstrate that farmers do face broad and diverse barriers to the adoption of soil enrichment practices, that their personal barriers equate to commercial barriers, and that the mechanisms employed in this protocol present novel means to address such barriers. Incidentally, it is argued in this appendix that farmers do in fact face such pressures to a greater extent than do other parts of society, given the deep interrelationship of their personal and commercial interests.

A.1.1 Non-Financial Barriers to Adoption of Soil Enrichment Practices

The body of literature on the impact of soil enrichment practices on soil carbon stocks and overall emissions from agricultural operations is growing (Teague, et al., 2016), (Gravuer, Gennet, & Throop, 2019), (IPCC, 2019); however, information needed to project the financial outcome of implementing any one agricultural practice in a given region is lacking due to the emerging nature of soil enrichment practices. Since the 1990s, research on and implementation of soil enrichment practices has expanded. However, for the current generation of farmers, soil enrichment practices were not a part of university agricultural science curricula and are not widely practiced today. This educational gap results in systemic barriers to soil enrichment practices, as this sort of training drives decisions by not only farmers, but also the agronomists who advise them, seed, chemical, and equipment vendors, regulators, and farm lenders. Farmers may not be able to obtain financing if their banker disagrees with their management decisions. They may not even have the chance to make those decisions if those who advise them are not educated in these areas.

While costs and revenues associated with implementing one soil enrichment practice are largely unknown, the financial outcome of implementing combinations of multiple soil enrichment practices is even more uncertain. Furthermore, soil enrichment activities encompass an enormous variety of practices, with tremendous potential for development of new practices. It would not be practical or even feasible to compile financial data on the full suite of existing practices much less potential future practices. This protocol adopts a standardized method for the determination of additionality for the project activity class based on demonstration of widespread risk aversion in the agricultural sector globally. This appendix includes an assessment of behavior in the agricultural sector that is not focused solely on long-term profitability, but rather is driven by a wide variety of motivations, including local agricultural tradition and cultural inertia that slows the adoption of new agricultural practices. While all humans make decisions in certain aspects of their lives that are not purely driven by economic factors, farming as a commercial enterprise faces unique conditions which accentuate the importance of values other than long-term profitability and the ramifications of decision-making that incorporates such values. Revenue from the sale of GHG credits may work to surmount such barriers to new practice adoption by financing the work of project proponents to address barriers related to cultural tradition and to perceptions of risk associated with the adoption of soil enrichment practices. GHG credit revenues may enhance the potential magnitude of the profitability of practice change(s), while also accelerating the timeline of those gains.

Studies of these barriers to practice adoption demonstrate it is difficult to get farmers to change their behavior for a variety of reasons. Research conducted via grower interviews focused on identifying the psychological barriers to the adoption of soil enrichment practices. These conversations highlighted barriers to soil enrichment practice adoption including:

- Barriers associated with existing market structures and a lack of motivating incentives to get farmers to shift practices.
- Barriers associated with whether farmers believe they can feasibly adopt new practices, implications of decisions, and their feelings towards risk.
- Barriers associated with openness to new ideas, the perceived magnitude of the shift, and their trust of the messenger.
- Barriers associated with the story farmers tell themselves about who they are, their values, and how they fit into their community.

The presence and influence of these barriers are supported by the larger consensus of peer reviewed research, as detailed in Section A.1.2.

A.1.2 Farmer Decision Making Under High Uncertainty and High Risk

Significant academic research has explored the subject of farmer decision making, seeking to develop a stronger understanding of motivations and decision-making factors. Until recently, much of the academic literature used an economic rationalizer/maximizer lens that made significant assumptions about the motives or decision-making methods as well as condition or context in which farmers make decisions. This traditional economics approach often concluded that increased economic incentives would drive grower decisions to adopt practices with reduced environmental and societal externalities. Under that approach, simply paying farmers more for better practices would provide clear information that farmers would include in their decision making toward a more rational economic outcome.

More recent research has focused on questioning and analyzing the actual pathways to farmer decision making. If in fact farmers are not focused purely on long-term profitability (as exemplified from the past 40 years of conservation subsidization at state and federal levels),[30] just how (and why) do they make their decisions? What are the key factors that determine adoption of new practices? How might government or private market programs best approach farmers to encourage behavior change to address numerous externalities?

To fully understand farmer decision making, one must start with understanding the context in which they operate. If farmers were to make decisions based purely on maximization of long-term profitability, they would need the right conditions to support such decision-making. Those include having clear and accurate information, responsive and timely outcomes to decisions, few uncontrollable variables, and minimal barriers to adjusting decisions and behaviors. This context works for basic quick and repeated consumer purchasing decisions within well-established markets involving many buyers and sellers. However, farmers' situations are quite different from that ideal. Farmers experience considerable uncontrolled variables in their farming. From weather to markets to pests and diseases, farmers are almost entirely reliant on factors outside of their control (Menapace, Colson, & Raffaelli, 2012). They also experience a long delay between decision and outcome, often months and sometimes years between the initial decision and receiving first evidence of success or failure due to the length of agronomic and economic cycles. Farmers also experience considerable initial costs to changing practices, often with long payback periods (Aimin, 2010). Thus, despite evidence that soil enrichment

[30] Despite the fact that many of the official USDA NRCS Conservation Practice Standards can enhance long-term profitability of agricultural operations, and have been promoted for decades, these standards have only been adopted at any significant scale in response to direct incentive payments from government programs.

practices may increase long-term profitability, while also potentially making farms more resilient to changes in some of the uncontrolled variables mentioned above, the natural and economic realities described above hinder adoption of these practice changes.

There are also structural barriers faced by growers who want to implement certain practice changes. Crop insurance is an area of particular importance in this regard. In order to achieve financial protection against crop performance problems, most growers enroll in some form of government-sponsored crop insurance. However, these programs generally have very prescriptive activity requirements. In some cases, these requirements can slow, or completely prevent, adoption of soil enrichment practices. For example, when growers experience a “prevented plant,” where weather conditions delayed planting of a crop within the appropriate time window, they face restrictions on the use of cover crops, resulting in many acres remaining fallow for an entire season.

This context has a significant impact in how farmers make decisions, from their cropping choices to their social interactions. In addition, farmers make occupational and other significant decisions using a range of values. While it is true that many people in many occupations make choices using a range of values, from economic utility to enjoyment of the occupation to social benefits, these additional values play a heightened role for many farmers due to the heightened degree to which their occupations both enable and compel them to embrace values of independence and family-based lifestyle, relative to other professions. This largely arises from the fact that farming is not a “job” in the conventional sense because the farm is not only a commercial enterprise, but also a home, a legacy, and a personal identity. In this context, personal and commercial decisions cannot be decoupled. This is a truly unique context in which few others experience the level of uncertainty and risk combined with opportunity of social non-pecuniary values. These factors, particularly when combined with the public nature of agriculture in which practices are readily visible to others, makes it open to intense scrutiny by those outside and inside of farmers’ social networks. This can impact their identity and compel them to implement strategies to satisfy internal identity and external social pressure, as opposed to simply maximizing economic outcomes.

This combination of factors leads farmers to pursue decision-making that is not purely driven by economic factors, for instance by seeking risk avoidance as a primary goal (Stuart, 2014) (Menapace, Colson, & Raffaelli, 2012). Due to long delays between decisions and outcomes, coupled with the reality that they have literally thousands of different options within a context of thousands of different conditions due to multiple uncontrolled variables, farmers seek to restrict the range of choices they need to consider. The primary method by which they restrict choices is through satisficing (Dayde, Couture, Garci, & Martin-Clouaire, 2014). Farmers employ a range of filters to sift out unacceptable options. Some filters include initial capital cost, social norms, and fit with identity (Findlater, Satterfield, & Kandlikar, 2019). Initial capital cost is an obvious filter, as finances rationally constrain options. Financial support for the adoption of improved practices can successfully aid farmers in overcoming this natural barrier. Social norms and identity, however, reflect satisficing strategies that significantly constrain the boundaries of viable options for farmers and, at the same time, have little response to financial incentives. Farmers, as commercial enterprises, are strongly influenced by social norms to a greater degree relative to those in other occupations (Sutherland, et al., 1996) (Liu, Bruins, & Herberling, 2003). Farmers’ perception of risk of a practice is correlated to perception of that practice fitting social norms (Singh, Dorward, & Osbahr, 2016). The fear of peer shaming and the desire for peer validation through alignment of implemented practice to social norm further restricts farmer consideration of otherwise economically rational or agronomically viable farming practices (Findlater, Satterfield, & Kandlikar, 2019), (Earls, 2009).

Additionally, farmers limit the distance into the future in which they will address problems as well as employ heuristics, or past experience, to further limit the decisions they need to make and options or strategies they are willing to consider (Findlater, Satterfield, & Kandlikar, 2019). This is a strategy to minimize decision paralysis brought on by the overwhelming number of future scenarios and choices farmers could make in a world with considerable variables and high uncertainty. Farmers will also use heuristics to provide mental models or metaphors through which to understand fairly abstract agronomic strategies (Dayde, Couture, Garci, & Martin-Clouaire, 2014). Human decision tendencies will also incline farmers to place more emphasis on risk avoidance than profit maximization in high risk scenarios. These strategies put a heavy emphasis on past experiences as guides for the future, in the process resulting in decision making that heavily emphasizes the status quo (Kahneman, 2003), (Dayde, Couture, Garci, & Martin-Clouaire, 2014), and (Aimin, 2010). Only after options have passed through these filters may they be considered viable, regardless of potential profitability or available financial incentives.

Another thread of research examining farmer decision making has explored the role of identity. Decisions, especially those with long delays (risk) and numerous variables (uncertainty) will be increasingly influenced by an individual's identity, which fills in the void of certainty and clear information. Behavior becomes the tool by which humans express their identity in particular settings. For farmers, the tool of expression is visible agronomic practices, which are readily observable by others in their desired community/identity. This visibility further accentuates the role of identity and implementing behaviors to adhere to perceived actions befitting a particular identity. Future decisions get influenced by the perceived or expected feedback received from others in their community. The same can be said for many others in society, but these pressures are accentuated for farmers insofar as they are also sole actors in a commercial enterprise, and as they operate in particularly high-risk, low control environments (greatly at the mercy of external factors such as weather). In light of this expected feedback, farmers will adjust behaviors to receive positive feedback and avoid negative feedback (McGuire, Wright Morton, & Cast, 2013), (Liu, Bruins, & Herberling, 2003). Farmers also overwhelmingly see themselves as "good farmers." When new practices are presented as advantageous or better than their current practices, farmers perceive such practices as a threat to that identity. In that situation, people will seek to disregard, discount, or deny new evidence rather than having to view themselves as not adhering to their primary identity (Syed, 2015). In some situations, farmers may not necessarily see the suggestion of a new practice as an immediate threat to their identity; however, their limited knowledge of implementing that new practice may result in the same process and outcome of avoiding implementation in order to avoid failure (either in ability to implement or in crop yield outcome of reduced crop yields) that would challenge their identity as a good farmer (Wilson, Schlea, Boles, & Redder, 2018), (Stuart, 2014).

Based on this more complete understanding of farmer decision making, key strategies may be implemented to improve efforts to move farmers to adopting practices that exhibit positive economic outcomes with reductions in environmental externalities. As indicated, simply increasing the long-term financial return of preferred practices is insufficient to change behaviors (Howley, Buckley, O'Donoghue, & Ryan, 2014). As such, financial incentives (such as carbon offset revenues) should be designed and offered with risk reduction as the primary purpose and should be communicated as such to farmers. Framing preferred practices as key risk-mitigating strategies will be vital to accomplish broad adoption goals. Further, preferred agronomic practices must be presented in ways that allow farmers to see how such practices fit existing social norms and farmers' identity. Finally, outreach must include efforts to simplify implementation to increase farmer perception of self-efficacy. Ultimately though, our contention is that it is not necessary for this protocol to mandate the broadest suite of actions to comprehensively address all aspects of the various barriers faced by farmers. Instead, it is contended that it is sufficient to demonstrate that providing offset revenues and mandating robust GHG accounting and longevity of SOC impacts—with proper incentives to ensure such longevity—is sufficiently unique to make projects under this protocol additional.

A.1.3 Trends in Adoption of Soil Enrichment Practices

As shown in a long-term assessment published by the USDA, conservation practices which have been promoted by the department, mainly through the NRCS, have seen mixed levels of success in recent decades (Baranski, et al., 2018). For certain crops, in certain regions, certain practices have increased adoption, while other combinations of these have seen flat or decreasing adoption rates. Nationally, there are few clear success stories. While no-till farming has made strong gains in wheat, it has remained flat for corn, and showed losses for soybeans. What the data do not show, however, is the extent to which these practices are maintained over the long term, and to what extent they are effective at generating environmental benefit, especially in regard to GHG impacts. By focusing on measured performance, and requiring permanence, the SEP is setting a higher bar for the application of sustainable agricultural practices over a long period of time.

A.1.4 Discrete Change and Practice Adoption Over Time

Offset protocols normally conceptualize the project activity as a single, binary event. The project begins on the start date, fully formed, and continues operation largely unchanged through the entirety of the crediting period. For example, a landfill gas control system begins operation at a discrete point in time and operates fairly continuously for decades. The “baseline” period and the “project” period are clearly defined. However, with agricultural land management, this is often not the case, further complicating the approach to determining additionality. Many farmers have to make at least minor adaptations from year to year for weather and market conditions. However, as described in earlier sections, they make these management decisions based on conventional wisdom and business as usual practices. Not only are there significant barriers to a single change in practice, but these barriers are compounded when a farmer is faced with the prospect of multiple practice changes to achieve the full benefits of sustainable agricultural land management. In reality, farmers will tend to adopt new practices in a piecemeal way, going further into sustainable management only when they are comfortable with the performance of the initial steps (Brown, 2018).

Thus, a single practice change is likely to be the only viable point of entry for the majority of conventional farmers. At the same time, it is also likely to lead to multiple practice changes over time as the farmer’s comfort level increases and they begin to understand better the linkage between practice change and offset revenue.

A.2 Development of the Common Practice Assessment

Based on available data, Reserve staff determined it feasible and appropriate to develop a list of practices that have such prevalence, in specific locales, that it could be argued they are not additional, and should therefore be ineligible. Following analysis of uptake rates, Reserve staff have developed a *negative list* of specific practices, in specific counties, that are considered non-additional. In addition to the thesis on barriers to uptake presented in Section A.1, Reserve staff took into consideration several further factors in developing both an uptake threshold, as well as the development of farm-specific means to mitigate such inclusion on the *negative list*. During development of the protocol Reserve staff received advice from agronomic experts that bolstered the notion a single practice adoption, including the adoption of a single change in tillage practices, is likely to be the safest and most practical means by which agricultural land managers can move towards adoption of more sustainable farming systems. Further factors taken into consideration included information contained in work performed by the USDA's Economic Research Service (ERS), which indicates that while uptake rates of practices such as no-till may be prevalent in certain counties, data suggests that only 21% of total acres exhibited such practice adoption over multiple years, while other adopters continued to rotate such practices with conventional tillage.[31] Such data also suggests that the adoption of several such practices on any given field is not common practice. In addition to such data and qualitative assessments, Reserve staff took into consideration feedback from multiple parties in support of such an approach.[32]

Based on the above factors, and data from the USDA's National Agricultural Statistics Service (NASS),[33] Reserve staff determined it appropriate to set a threshold of activity uptake of 50% within a given county, as the threshold above which such uptake should be deemed not additional. Only those activities for which there is uptake of the single given activity, in a given county, of above 50%, are such activities deemed not additional on any given field. Given the relatively high uptake rates of some practices, as evidenced by the data cited in this analysis, the barriers analysis, and further factors presented above, the Reserve believes it appropriate to offer a finite window of time to agricultural land managers to experiment with such new practices, before then moving on to adopt further such practices. The resulting carbon revenues accruing through the sustained implementation of even a single new practice, followed by increased incentives earned through the sustained implementation of further such practices, should provide a clear driver for agricultural land managers to move towards farming systems that contribute towards greenhouse gas emission reductions, whilst minimizing the risk of crediting for practices that would have occurred in the absence of the project.

To estimate uptake rates, the Reserve studied multiple sources of data, and settled on use of data made available by the National Agricultural Statistics Service (NASS).[34] Using such data Reserve staff estimated uptake rates at the county level for no-till, reduced-till, cover crops, rotational grazing and/or intensive grazing.[35] The uptake rate for no till, reduced till and cover crops was defined according to Equation A.1. The uptake rate for rotational grazing and/or intensive grazing was defined using Equation A.2.

Equation A.1. Calculation of Uptake Rate for Cropping Practices

$$\boldsymbol{Uptake\ rate = \frac{Number\ of\ acres\ that\ applied\ practice\ at\ county\ level}{Total\ cropland\ acres\ at\ county\ level}}$$

[31] Economic Research Service, 2018. Tillage Intensity and Conservation Cropping in the United States. United States Department of Agriculture. Available at: https://www.ers.usda.gov/publications/pub-details/?pubid=90200
[32] See public comment letter from Newcombe et al. (June 2020) at: http://www.climateactionreserve.org/wp-content/uploads/2020/09/SEP-Public-Comment-August-Newcombe-et-al.pdf.
[33] https://www.nass.usda.gov/
[34] https://www.nass.usda.gov/
[35] NASS groups together the uptake rate for rotational and intensive grazing. If a county has a prevalence of more than 50% of its operations for that particular data point, both rotational grazing and intensive grazing are ineligible under the protocol as it is not possible to discern which of the two practices is the prevalent one in a given county.

Equation A.2. Calculation of Uptake Rate for Grazing Practices

$$\boldsymbol{Uptake\ rate = \frac{\begin{matrix}Number\ of\ rotational\ grazing\\ or\ intensive\ grazing\ operations\\ at\ county\ level\end{matrix}}{\begin{matrix}Number\ of\ pasture\ operations\\ at\ the\ county\ level\end{matrix}}}$$

The data for these calculations were obtained from the National Agricultural Statistics Service (NASS) through the following queries:

Acres and number of operations per practice	
Program	CENSUS
Sector	ECONOMICS
Group	FARMS & LAND & ASSETS
Commodity	PRACTICES
Data Item	▪ PRACTICES, LAND USE, CROPLAND, CONSERVATION TILLAGE, (EXCL NO-TILL) – ACRES ▪ PRACTICES, LAND USE, CROPLAND, CONSERVATION TILLAGE, NO-TILL – ACRES ▪ PRACTICES, LAND USE, CROPLAND, CONVENTIONAL TILLAGE – ACRES ▪ PRACTICES, LAND USE, CROPLAND, COVER CROP PLANTED, (EXCL CRP) – ACRES ▪ PRACTICES, ROTATIONAL OR MGMT INTENSIVE GRAZING - NUMBER OF OPERATIONS
Geographic level	COUNTY
Year	2017

Total cropland acres and pastureland operations per county	
Program	CENSUS
Sector	ECONOMICS
Group	FARMS & LAND & ASSETS
Commodity	AG LAND
Data Item	▪ AG LAND, CROPLAND – ACRES ▪ AG LAND, PASTURELAND – NUMBER OF OPERATIONS
Geographic level	COUNTY
Year	2017

Appendix B Illustrative List of Soil Enrichment Practices

As described in Section 3.4.1, a soil enrichment project must adopt one or more changes in pre-existing agricultural management practices which are reasonably expected (over the project crediting period) to increase SOC storage and/or reduce emissions of CO_2, CH_4, and/or N_2O from agricultural land management activities.

Land management practices considered for soil enrichment projects are those which are expected to achieve one or more of the following results on the project area:

- Increased duration of the presence of living roots in the soil
- Reduced chemical inputs (particularly nitrogen fertilizers)[36]
- Reduced use of fossil fuels for the operation of equipment
- Reduced or eliminated mechanical disturbance of the soil
- Increased diversity of plant species cultivated in regular cycles
- Protection of top soils (soil armor)
- Integration of beneficial livestock practices

Table B.1, below, lists several potential practice changes which could be eligible to define a soil enrichment project. This list is not comprehensive.

Table B.1. Illustrative List of Soil Enrichment Project Activities

Category	Suggested Practice Changes
Crop selection and rotation	▪ [baseline practice, not eligible for additionality] Continuous cash crop (monoculture) ▪ Rotational (2 crop) cash crop ▪ Rotational (3+ crop) cash crop ▪ Continuous cash crop with cover crop ▪ Rotational cash crop (2 crop) with cover crop ▪ Rotational cash crop (3+ crop) with cover crop ▪ Continuous cash crop planting into living cover crop ▪ Rotational cash crop (2 crop) planting into living cover crop ▪ Rotational cash crop (3+ crop) planting into living cover crop ▪ Relay cropping ▪ Companion or intercropping of cover crop with cash crop during the same growing season
Use of cover crops	▪ Plant cover crops, annual ▪ Plant cover crops, perennial ▪ Plant leguminous cover crops, annual ▪ Plant leguminous cover crops, perennial ▪ Plant multi-species cover crops, annual ▪ Plant multi-species cover crops, perennial ▪ Interseeding cover crops, annual/perennial ▪ Interseeding leguminous cover crops, annual/perennial ▪ Interseeding multi-species blend cover crops, annual/perennial

[36] There may also be non-GHG positive impacts, or co-benefits, associated with a reduction in the use of other chemical inputs, such as pesticides, however the quantification approach in this protocol will focus on GHG impacts of fertilizers, and not include estimation of the GHG impacts of reduced use of other chemicals.

Category	Suggested Practice Changes
Tillage	▪ Moldboard (2-10”) (baseline practice, not eligible for additionality) ▪ Disk/chisel (2-10”), <50% residue remaining ▪ Disk/chisel (2-10”), >50% residue remaining ▪ Vertical tillage (1-2”), <50% residue remaining ▪ Vertical tillage (1-2”), >50% residue remaining ▪ Strip till, <50% residue remaining ▪ Strip till, >50% residue remaining ▪ No-till
Fertilizer management*	▪ Synthetic fertilizer without optimization (baseline practice, not eligible for additionality) ▪ Synthetic fertilizer: optimize application or practice split application, surface applied or broadcast ▪ Synthetic fertilizer: optimize application or practice split application, and apply subsurface or with controlled-release (nitrogen stabilizer) ▪ Organic fertilizers
Irrigation management	▪ Flood irrigation ▪ Standard irrigation (defined as >X gal/ac) ▪ Standard irrigation (defined as <X gal/ac) ▪ No irrigation ▪ Rice only: Minimize annual flood days (<X days/year)
Livestock management	▪ Stock pasture (no rotation) ▪ Rotational pasture (rotate every 2+ days) ▪ Multi-species rotational pasture ▪ Rotational pasture (rotate every day or more frequently)

* Note: The protocol should allow for accounting for impacts on SOC of other amendments, such as biochar, insofar as such impacts are captured during direct measurement of SOC. It is less likely that models are currently able to capture impacts of less commonly used amendments.

B.1 Migration of Soil Organic Carbon When Employing No-Till

As set out in Section 6.5.1, fields which historically continuously (i.e., more than once for the same crop) tilled to depths deeper than 20 cm in their historical baseline period, and then go on to employ no-till in their project scenario, will not be eligible to be credited for SOC gains. See Section 3.4.1.3 for requirements on setting the baseline.

Based on literature including two meta-analysis and feedback provided by the workgroup and during the public comment periods, Reserve staff have determined the above-referenced tillage practices should be excluded from eligibility to generate SOC-related credits, in order to ensure no over-crediting occurs. In a meta-analysis conducted by Luo et al. (2010), evidence was presented that indicated that when moving from conventional tillage to no-till, SOC may migrate upwards into the top 30 cm from deeper soil depths. Following a review of the analysis in Luo et al. (2010), recommendations from the workgroup included that it would be appropriate to set minimum sample depth either at 40 cm or at 15 to 20 cm below plow depth. This recommendation was based on information in Table 1 of the Luo et al. paper, which indicated the typical plow depth in the underlying studies assessed were at around 25 cm, and various summaries throughout the report that indicate that sampling up to 20 cm below that historical plow depth captured the majority of SOC migration. The notion that sampling at around historical plow depth is useful to capture potential SOC migration, also appears to be supported by the meta-analysis undertaken by Angers et al. (2008), where typical plow depth was 25 cm and average sample depth some 26-35 cm.

Based on discussions with agronomists, and research conducted by Reserve staff, the Reserve has been able to determine the historical plow depth of various conventional tillage practices. Following this analysis, it was determined that all but two conventional tillage practices (moldboard and deep ripper) typically disturb soil to depths between 10-20 cm, and that deep tillage is employed relatively rarely in the U.S. From this, the Reserve is able to determine that for the vast majority of fields, a soil sample to 30 cm would typically allow for observance of potential SOC migration within the soil profiles 10-20 cm below the historical plow depth. Based on the work presented by Luo et al. (2010) and Angers et al. (2008), and recommendations from the workgroup, setting a minimum sample depth some 10-20 cm below historical plow depth should effectively ensure material impacts of SOC migration are captured.

It is worth noting that the work done by Luo et al. (2010), and work done by Chenu et al. (2019) and Angers et al. (2008), indicates the adoption of no-till in conjunction with other conservation practices can significantly increase SOC stocks. The study by Chenu et al. (2019) went further to propose that combining no till with other conventional practices is probably the best way to ensure SOC increases relative to any migration in SOC from deeper layers. Thus, if fields adopting no-till go on to stack further sustainable practices, as the Reserve envisages the majority of fields will do, this will further reduce the risk that sampling to 30 cm leaves a material amount of SOC migration undetected. Taken together, the Reserve believes these factors ensure that the risk of over-crediting due to undetected material amounts of SOC migration from deeper layers, is reasonably mitigated.

Appendix C Assessing Leakage for SEP Projects

This protocol requires monitoring and accounting for the potential leakage related to the project activities in cases where livestock are displaced out of the project area or there is a sustained reduction in yield from primary cash crops. There is precedence in carbon accounting for limiting the need for accounting for leakage where the project activities occur on land used for agricultural production, such as section 3.7.12 of the VCS Methodology Requirements v4.0 (Verra, 2019). Under these VCS requirements projects must develop a project description that includes a commitment to no substantive leakage, and thus commit to ensuring no such leakage takes place. Under the VCS requirements projects must also account for any activity-shifting leakage associated with reduced stocking of the project area during the reporting period, relative to baseline historical stocking rates.

The main concern around leakage for soil enrichment projects would be through a reduction in commodity yield caused by project activities or displacement of livestock grazing activities. In theory, reduced output from project fields would result in increased output from fields outside of the project, either through increased efficiency (no leakage) or through conversion of new land for commodity production (leakage). This conversion of new land could be through activity shifting leakage, whereby the grower converts other acres under their control, or market shifting leakage, whereby other growers convert new acres to commodity production.

A meta-analysis of 610 studies concerned with the effects of no-till, use of cover crops or significant crop residues, and use of crop rotations found that there are potential short-term declines in crop yield, but that these short term effects are recovered over time, with no significant loss in yield as practices are maintained for several years (Pittelkow, et al., 2014). A soil enrichment project crediting period is 10 years (potentially renewed up to two times, for a total potential crediting period of 30 years), which is more than sufficient to erase these potential short-term yield declines. Thus, the approach to monitoring and assessing leakage related to cash crop yield declines adopted by this protocol relies on a government metric for long-term yield (see Section 5.5).

The agricultural sector is subject to many barriers to change (as discussed in Appendix A) and inefficiencies. Decreased yields would need to be large and sustained over time in order to generate sufficient incentive for land conversion elsewhere. Decreases of this magnitude are not expected from soil enrichment project activities. Importantly, there are two forces limiting significant yield declines on the project area:

1. **Farmer risk aversion**

   As discussed in Appendix A, farmers are incredibly risk averse. Decline in yield has an immediate and directly correlated effect on farm income. The revenue from carbon credits is meant to overcome the costs associated with adopting new management practices and behavior changes. Carbon revenues are not designed to replace the farmers' primary source of income: crop production. Any significant yield decline is likely to cause a farmer to exit the program and resume their pre-existing management regime, thus avoiding market-shifting leakage.

2. **Quantification of emission reductions**

   A secondary guardrail against significant yield declines is the fact that productivity is linked to the predicted SOC accumulation in biogeochemical models. The yield at harvest is one of the most sensitive dependent variables to a biogeochemical model predicting SOC. A lower yield will cause the model to assume the field was less productive, and lead to fewer emission reductions because of reduced SOC accumulation. Thus, there is an in-built incentive to maintain yields in order to enhance crediting for emission reductions.

Based on the above, this protocol adopts a targeted approach to assessing and accounting for potential emissions leakage from soil enrichment project activities. By comparing yield trends in the project area to yield trends in the relevant region, it is possible to detect declines related to project activities separately from overall market shifts due to weather, genetics, and market conditions.

Appendix D Quantifying Uncertainty

In SEP projects, the goal is to estimate the total emissions reduction in time period t, denoted by ER_t. The estimate of that total emissions reduction, denoted by $\widehat{ER}_t$, is made using measurements and model predictions on a subset of the project's fields selected through a random sample. It is important for a project developer to identify sources of uncertainty arising during estimation of GHG emission reduction. Such sources of uncertainty relevant to estimation of GHG emissions reduction, including common limitations and data gaps, are extensively discussed in Eve et. al. (2014) and IPCC (2019). The estimate of uncertainty quantifies the precision of estimated GHG emission reductions and is used to calculate the uncertainty deduction (Section 5.2). Therefore, it is important to account for all sources of uncertainty, whenever possible, using statistical methods that provide sound estimates of uncertainty that are accurate and conservative. At a minimum, the following three sources of error contribute to the uncertainty of ER_t, and each of these sources of error must be accounted for:

1. **Sample error** resulting from measuring and modeling only a portion of the project
2. **Measurement errors** of values such as soil carbon concentration, soil texture, and bulk density provided as inputs to the model
3. **Model prediction errors**

This appendix describes two alternative approaches to uncertainty quantification. Approach 1 in Appendix D.1 is an analytical method for error propagation. Approach 2 in Appendix D.2 is a methodology relying on Monte Carlo simulation. For each modeled source of emissions, project developers may choose which of these two approaches to use. As shown in Figure D.1, the results of that calculation are then used to estimate the margin of error (Appendix D.3) and the uncertainty deduction (Appendix D.4).

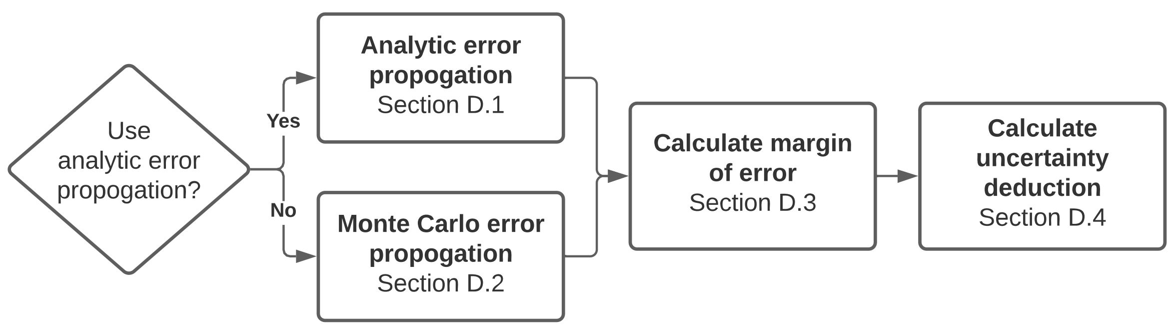

Figure D.1. Overall steps in quantifying uncertainty. Different error propagation methods can be used for different sources of emissions.

D.1 Approach 1: Analytical Method for Error Propagation

Approach 1 is based on analytical error propagation and uses a frequentist approach to estimate uncertainty of total GHG emission reduction. This approach is computationally simpler than Approach 2.

D.1.1 Model Prediction Error

Errors of the model are calculated from validation datasets where ground truth measurements of emissions can be compared with the model's predictions. Assuming that the model is unbiased, the uncertainty of a model's prediction is captured by the variance of its errors, which are estimated using validation datasets.

The ideal validation data would be field trials in which practices that simulate a project scenario are used in one part of the field and practices that simulate a baseline scenario are used in another part of the same field. Then errors of the project minus baseline emission reductions of a certain gas or pool in cultivation cycle *t*, ΔG_t, can be computed directly at each site *i* using $error_{\Delta G,i} = \widehat{\Delta G_i} - \Delta G_i$, and the uncertainty from the model is estimated as the variance of $error_{\Delta G,i}$ across all sites i in the validation data for cultivation cycle *t*.

Because such field trials (and associated model predictions) are rare, the task can be split into two separate tasks:

1. model predictions and ground truth measurements can be used to estimate typical errors of the prediction of emissions in just one scenario (e.g., just the project scenario), and
2. the correlation of errors between project and baseline scenarios can be estimated from the field trials described above.

Assuming that the variance of the model prediction is the same in the project and baseline scenarios [i.e., $\mathbf{Var}\left(\widehat{G_{pr}}\right) = \mathbf{Var}\left(\widehat{G_{bl}}\right)$, which we denote by $s^2_{model,G}$], we have

$$\mathrm{Var}\left(\widehat{\Delta G}\right) \equiv \mathrm{Var}\left(\widehat{G_{bl}} - \widehat{G_{pr}}\right) = 2\left[s^2_{model,G} - \mathrm{Cov}\left(\widehat{G_{bl}}, \widehat{G_{pr}}\right)\right]$$

By writing $\mathbf{Cov}\left(\widehat{G_{bl}}, \widehat{G_{pr}}\right)$ in terms of a correlation coefficient:

Equation D.1.

$$\rho = \frac{\mathrm{Cov}\left(\widehat{G_{bl}}, \widehat{G_{pr}}\right)}{\sqrt{\mathrm{Var}\left(\widehat{G_{pr}}\right)\mathrm{Var}\left(\widehat{G_{bl}}\right)}}$$

We have:

Equation D.2.

$$s^2_{model,\Delta G} \equiv \mathrm{Var}\left(\widehat{\Delta G}\right) = 2\, s^2_{model,G}\,(1-\rho)$$

where:

$s^2_{model,\Delta G}$	=	Estimated variance of the model's prediction of the baseline-minus-project difference in emissions of gas or pool G at one location
$s^2_{model,G}$	=	Estimated variance of errors made by the model's prediction of emissions of the gas or pool G (estimated from measurements in fields that need not be side-by-side trials with baseline and project scenarios)
ρ	=	Correlation of errors in project and baseline scenario pairs (which is estimated from side-by-side field trials with baseline and project scenarios)

Because side-by-side trials are rare, ρ is estimated from fewer data points than $s^2_{\mathrm{model},G}$. Data for quantifying model structural error may be sourced from studies conducted external to the project area, and the data shall be from the same datasets used to validate that the model is unbiased (per guidance in the *Model Requirements and Guidance* document).

If the amount of data for quantifying model structural uncertainty varies significantly among crops and regions, then structural model uncertainty could be estimated for groups of similar sites (e.g., based on a stratification applied to the fields in the project and to the sites in the validation data, or based on a Gaussian Process fit to the validation data with biophysical variables, management practices, and/or other variables as predictors). That way, a structural model uncertainty can be assigned to each field *i*: $s^2_{\mathrm{model},\Delta G,i}$.

This variance $s^2_{\mathrm{model},\Delta G,i}$ is calculated as an average of the variances for each of the model runs that form the baseline. For example, consider a baseline formed by 5 cultivation cycles in the historical period. For each of those cultivation cycles indexed by $j = 1, \ldots, 5$, the difference in project and baseline model runs gives an estimate of the emissions reduction $\Delta G_{t,i}$, denoted by $\widehat{\Delta G_{t,i,j}}$. Averaging those five estimates gives the estimate of the emissions reduction: $\widehat{\Delta G_{t,i}} = \frac{1}{5}\sum_{j=1}^{5} \widehat{\Delta G_{t,i,j}}$. Similarly, for cultivation cycle j in the historical period, there is a variance $s^2_{\mathrm{model},\Delta G,i,j}$ of the predicted difference between the baseline emissions (for that cultivation cycle j) and the project emissions. These variances are also averaged: $s^2_{\mathrm{model},\Delta G,i} = \frac{1}{5}\sum_{j=1}^{5} s^2_{\mathrm{model},\Delta G,i,j}$.

Finally, $s^2_{\mathrm{model},\Delta G}$ (Equation D.2) is an estimate of the population-average model error variance across the project (or across the stratum), using an estimator appropriate for the sample design used. For example, for a simple random sample or for the self-weighting two-stage design described in Appendix D.1.3, $s^2_{\mathrm{model},\Delta G}$ is an average of the $s^2_{\mathrm{model},\Delta G,i}$ across the sample sites i [Cochran (1977), eq. 13.39].

D.1.2 Model Input Measurement Error

Inputs to the model will inevitably have measurement error. Provided that these measurement errors in model inputs translate to measurement errors in model predictions that are uncorrelated across sample points, these errors are automatically captured by the estimate of sample error, discussed below. [See, for example, Cochran (1977, p. 382); de Gruijter et al. (2006, p. 82); Som (1995, p. 438).] QA/QC procedures for model inputs ensure that model inputs are sufficiently accurate and that measurement errors are uncorrelated with each other.

D.1.3 Sample and Measurement Error

Here we give an example of a two-stage design with first-stage units chosen with probability proportional to their acreage (with replacement) and with second-stage units chosen with simple random sampling (with replacement). For example, the first-stage units could be fields that are tiled with a fine grid; the second-stage units are tiles within the grid. This design could be modified in many ways, for example by assigning fields to strata, or by eliminating fields as a sampling unit and instead creating strata of tiles. Sample designs that select fields without replacement may also be used, provided that the estimators of variance are changed accordingly (see, e.g., Tillé 2006, chapters 5 and 7).

In the first stage, n out of N fields are selected with probability proportional to their size (e.g., acreage) with replacement. (For example, accumulate field sizes to form intervals of length equal to each field's area: [0, A_1), [A_1, $A_1 + A_2$), [$A_1 + A_2$, $A_1 + A_2 + A_3$), …, (A_1 + … + A_{N-1}, A); then draw n numbers randomly between 0 and the total area A, and for each draw record which field's interval it falls into.) If a field is chosen multiple times, then tiles are independently selected from that field multiple times. Subsequent calculations are simplified by making the probability $\boldsymbol{\pi_i}$ of selecting field i equal to its area A_i divided by the total area A of all fields at the time of randomization, i.e., probability proportional to size (PPS) sampling:

Equation D.3.

$$\pi_i = \frac{A_i}{A}$$

Within each selected field i, m_i tiles are chosen with simple random sampling with replacement. The estimator of the emission reductions averaged across all tiles is the simple (unweighted) average across all sampled fields and sampled tiles [Som (1995), eq. 16.19; Cochran (1977), eq. 11.39]:

Equation D.4.

$$\widehat{\overline{\Delta G_t}} = \frac{1}{n}\sum_{i=1}^{n}\widehat{\overline{\Delta G_{\iota,t}}} = \frac{1}{n}\sum_{i=1}^{n}\frac{1}{m_i}\sum_{j=1}^{m_i}\widehat{\Delta G_{\iota,J,t}}$$

where:

$\widehat{\overline{\Delta G_t}}$	=	Estimated average emissions reduction of gas or pool G in year t, in tCO_2e/acre/year
$\widehat{\overline{\Delta G_{\iota,t}}}$	=	Estimated average emissions reduction of gas or pool *G* in year *t* in field *i*, in tCO_2e/acre/year
$\widehat{\Delta G_{\iota,J,t}}$	=	Estimated emissions reduction of pool G at point j in field i, in tCO_2e/acre/year.
n	=	Number of sampled fields (and the sampled fields are assumed to have indices $1, 2, \dots, n$)

To fix the amount of work in each field, set m_i equal to a constant m across all fields. Then the design becomes "self-weighting," and Equation D.4 simplifies to an average across all measurements, $\widehat{\overline{\Delta G_t}} = \frac{1}{n\,m}\sum_{i=1}^{n}\sum_{j=1}^{m}\widehat{\Delta G_{\iota,J,t}}$.

Ignoring model errors, an unbiased estimator of the variance of $\widehat{\overline{\Delta G_t}}$ is, from [Som (1995), eq. 16.19; Cochran (1977), eq. 11.40],

Equation D.5.

$$s^2_{sample\,\&\,meas.,\Delta G,t} = \frac{\sum_{i=1}^{n}\left(\widehat{\overline{\Delta G_{\iota,t}}} - \widehat{\overline{\Delta G_t}}\right)^2}{n\,(n-1)}$$

D.1.4 Combined Uncertainty

To combine variance from model error (Appendix **Error! Reference source not found.**) with measurement and sample error (Appendix **Error! Reference source not found.**), we assume that the model errors are uncorrelated with the measurement values and are independent across samples. Then by [Cochran (1977), eq. 13.39; Som (1995), eq. 25.10], the variance of $\widehat{\overline{\Delta G_t}}$ incorporating sample error, measurement error, and model prediction error is

Equation D.6.

$$s_{\Delta G,t}^2 = s_{sample\,\&\,meas.,\Delta G,t}^2 + \frac{s_{\;model,\Delta G,t}^{\;2}}{n \times m}$$

D.1.5 Remeasured Soil Carbon Stocks

When the change in soil organic carbon stocks is periodically directly re-measured, uncertainties of model inputs and model prediction are eliminated from the project scenario. The estimate of the change in average carbon stocks in the project scenario from period $t-1$ to t is unbiasedly estimated by the difference of the estimates at the two time periods [Som (1995), eq. 24.15]:

Equation D.7.

$$\widehat{\overline{SOC}}_{\mathrm{pr},t} - \widehat{\overline{SOC}}_{\mathrm{pr},t-1}.$$

If a whole new set of sample points is chosen independently of the initial sample points, then the variance of **Error! Reference source not found.** is the sum of the variances [Som (1995), eq. 24.16]:

Equation D.8.

$$\mathrm{Var}\left(\widehat{\overline{SOC}}_{pr,t} - \widehat{\overline{SOC}}_{pr,t-1}\right) = \mathrm{Var}\left(\widehat{\overline{SOC}}_{pr,t}\right) + \mathrm{Var}\left(\widehat{\overline{SOC}}_{pr,t-1}\right)$$

Because the carbon stock at a site is highly correlated with the stock at that same site at a later date (with correlation coefficient denoted by ρ_S in Equation D.9 below), it is better to revisit the original set of sample points, so that, from [Som (1995), eq. 24.17],

Equation D.9.

$$\mathrm{Var}\left(\widehat{\overline{SOC}}_{pr,t} - \widehat{\overline{SOC}}_{pr,t-1}\right) = \mathrm{Var}\left(\widehat{\overline{SOC}}_{pr,t}\right) + \mathrm{Var}\left(\widehat{\overline{SOC}}_{pr,t-1}\right) - 2\,\rho_S \sqrt{\mathrm{Var}\left(\widehat{\overline{SOC}}_{pr,t}\right)\ \mathrm{Var}\left(\widehat{\overline{SOC}}_{pr,t-1}\right)}$$

D.2 Approach 2: Monte Carlo Method for Error Propagation

This section presents an approach to quantifying uncertainty using Monte Carlo simulations. Random samples are drawn from probability distribution functions of model inputs and/or of model parameters. For each draw, the biogeochemical model computes a prediction; then uncertainty is calculated from the distribution of these predictions across all draws. The MC method is well suited for nonlinear, deterministic, process-based biogeochemical models (e.g., DayCent, DNDC) because, unlike the analytical error propagation method in Appendix D.1, the MC method can more easily address key dependencies in the underlying data (such as correlation between model parameters) and asymmetric error distributions (such as non-negative or highly skewed distributions). The MC method is used in the USDA's approach for estimating emissions at the farm-scale (Eve et. al., 2014) and in the US National GHG Inventory (USEPA, 2020). The approach is also described in Ogle et. al., (2007, 2010) and Gurung et al. (2020).

The following subsections provide estimates of total and mean GHG emission reductions and associated variance for a project using MC simulations of biogeochemical model predictions. When using MC simulations of biogeochemical model predictions, the total variance is a combination of modeling and sampling variance, as described below.

The notation in this section is different than in previous sections, aligning with notation commonly used in sampling and Bayesian statistics, to better support use of these methods in a SEP project. Table D.1 provides a cross-reference with the notation in Appendix D.1. Key differences include:

- The observed outcome of interest (emission reductions) is denoted as y, which is commonly used in statistics to denote outcomes.
- Total emission reductions and areal mean emission reductions are denoted as τ and μ, respectively, in keeping with Thompson (2012). The use of lowercase Greek letters is also a reminder that the estimand of interest (true total and areal mean GHG emission reductions) are parameters that cannot be directly observed due to measurement error.
- MC draws of model-predicted emissions reduction are denoted as $\tilde{y}$. The tilde serves as a reminder that $\tilde{y}$ is a model prediction drawn from a posterior predictive distribution (following standard notation (Gelman et al., 2014; Hoff, 2009)) due to the use of Bayesian calibration (Kennedy et al., 2001).

The notation in Appendix D.2 also suppresses notation for the reporting period *t* and for the source of emissions (denoted by G in Appendix D.1). If a biogeochemical model is calibrated for multiple sources of emissions jointly, then the calculations in Appendix D.2 can be applied to the total emissions reduction (summed across those sources of emissions); otherwise, the calculations in Appendix D.2 are applied to each source of emissions individually, and the combination of estimates for different sources of emissions is detailed in Box 5.1 of the SEP and Equation D.20.

Table D.1 Notation cross-reference

Quantity	Notation: Appendix D.1	Notation: Appendix D.2	Units
Draws from posterior predictive distribution			
GHG emissions at a point for a particular source of emission under baseline and project scenarios, respectively (for two-stage design)	--	$\tilde{z}_{\mathrm{bl},ijl}$, $\tilde{z}_{\mathrm{pr},ijl}$	tCO_2e/acre
GHG emission reductions at a point for a particular source of emission (for two-stage design)	--	$\tilde{y}_{ijl}$	tCO_2e/acre
Total GHG emission reductions for a particular source of emission	--	$\tilde{\tau}_l$	tCO_2e
Single model predictions (not Bayesian)			
GHG emissions at a point for a particular source of emission under baseline and project scenario, respectively (for two-stage design)	$\widehat{G_{\mathrm{bl},\iota,J,t}}$, $\widehat{G_{\mathrm{pr},\iota,J,t}}$	--	tCO_2e/acre
GHG emission reductions for a particular source of emission (for two-stage design)	$\widehat{\Delta G_{\iota,J,t}}$	--	tCO_2e/acre
Estimated values			
Total GHG emission reductions for a particular source of emission	$A \times \widehat{\overline{\Delta G_t}}$	$\hat{\tau}$	tCO_2e
Areal mean GHG emission reductions for a particular source of emission	$\widehat{\overline{\Delta G_t}}$	$\hat{\mu}$	tCO_2e/acre
Variance of areal mean GHG emission reductions for a particular source of emission	$s^2_{\Delta G,t}$	$\widehat{\mathrm{Var}}(\hat{\mu})$	tCO_2e/acre
True population values			
Total GHG emission reduction for a particular source of emission	$A \times \overline{\Delta G_t}$	τ	tCO_2e
Areal mean GHG emission reductions for a particular source of emission	$\overline{\Delta G_t}$	μ	tCO_2e/acre
Area of field	A_i	A_i	acres
Total area of project	A	A	acres
Total number of fields in population	N	N	
Subscript for field selections (for two-stage design)	$i = 1, \ldots, n$	$i = 1, \ldots, n$	
Subscript for point selections (for two-stage design)	$j = 1, \ldots, m_i$	$j = 1, \ldots, m_i$	
Subscript for MC draws	--	$l = 1, \ldots, L$	

D.2.1 Target Parameter: Total GHG Emission Reduction

For a particular time period and emission source, the estimand, or target parameter[37] of interest, is the true total GHG emission reduction, denoted as τ, in metric tons of carbon dioxide equivalent (tCO_2e). Estimates of τ are denoted by $\hat{\tau}$. Similarly, the areal mean GHG emission reduction is denoted by μ (same as $\overline{\Delta G_t}$) in tCO_2e/acre. Estimates of μ are denoted as $\hat{\mu}$ (same as $\widehat{\overline{\Delta \mathrm{G}}}_t$).

D.2.2 Estimates of mean and total GHG emission reductions

Monte Carlo simulation can be used to estimate model prediction error through error propagation. At each sample point, GHG emissions are simulated under the baseline and project scenarios multiple times, indexed by $l = 1, \ldots, L$. The GHG emission reductions at each point are then calculated as the difference between predicted GHG emissions under baseline and project scenarios, as detailed in Equation D.10 for the two-stage sampling design described in Appendix D.1.3. Appendix D.2.4 below presents another sample design that has one stage.

Equation D.10.

GHG emission reductions for two-stage designs in which fields are the primary sampling units and points are the secondary sampling units:

$$\tilde{y}_{ijl} = \tilde{z}_{\mathrm{bl},ijl} - \tilde{z}_{\mathrm{pr},ijl}$$

where:

$\tilde{y}_{ijl}$	= Predicted GHG emission reductions for field selection i, point *j*, and MC simulation l (tCO_2e per acre)
$\tilde{z}_{\mathrm{bl},ijl}$	= Baseline scenario predicted GHG emissions for field selection i, point *j*, and MC simulation l (tCO_2e per acre)
$\tilde{z}_{\mathrm{pr},ijl}$	= Project scenario predicted GHG emissions for field selection i and MC simulation l (tCO_2e per acre)
i	= Field identifier ($i = 1, \ldots, N$) and N is the total number of fields
j	= sample point identifier ($j = 1, \ldots, m_i$) and m_i is the total number of sample points in field i
l	= Monte Carlo index ($l = 1, \ldots, L$), where L is the total number of MC Simulations

Note: Notation for the source of emissions is suppressed, as mentioned above. The sign convention is that $\tilde{z}_{\mathrm{bl},ijl}$ is emissions *to the atmosphere* in the baseline scenario. Thus, for the SOC pool, $\tilde{z}_{\mathrm{bl},ijl}$ is -1 times the predicted temporal change in SOC stocks in the baseline scenario; similarly, $\tilde{z}_{\mathrm{pr},ijl}$ is -1 times the predicted temporal change in the project scenario.

[37] The *estimand* is the quantity of interest (e.g., the true total GHG emission reductions/removals in the project scenario relative to a counterfactual baseline scenario), and an *estimator* is a method for estimating the value of the estimand (e.g., the mean GHG emission reductions/removals predicted by biogeochemical models at a random sample of fields or points). Similar to other research areas with complex study questions and analytic methods that undergo extensive review such as drug development and approval (e.g., see ICH 2020), the SEP clearly defines the estimand and estimator.

For the two-stage sampling design described in Appendix D.1.3, the total and areal mean are estimated as detailed in Equation D.11.

Equation D.11.

$$\hat{\tau} = \frac{A}{n}\sum_{i=1}^{n}\left(\frac{1}{m_i}\sum_{j=1}^{m_i}\left(\frac{1}{L}\sum_{l=1}^{L}\tilde{y}_{ijl}\right)\right)$$

where:

$\hat{\tau}$ = Monte Carlo estimate (MC mean) of total GHG emissions reductions for the project
$\tilde{y}_{ijl}$ = GHG emissions reduction for field selection i, point j, and MC simulation l (tCO_2e per acre)
A = total area of the project (acres)
n = number of field selections
m_i = number of points in field selection i
L = number of Monte Carlo simulations

and $\hat{\mu} = \hat{\tau}/A$ is the areal average GHG emissions reduction (tCO_2e per acre)

D.2.3 Combining sampling and model uncertainty

The uncertainty of the estimated total GHG emissions reduction in Equation D.11 can be decomposed into two components, sampling and modeling. Using standard variance decomposition (i.e., the law of total variance) following Del Grosso et. al. (2010), the total variance can be decomposed as:

Equation D.12.

$$\mathrm{Var}(\hat{\tau}) = \mathrm{Var}(\mathbb{E}[\hat{\tau}|\boldsymbol{s}]) + \mathbb{E}[\mathrm{Var}(\hat{\tau}|\boldsymbol{s})]$$

where:

$\mathrm{Var}(\mathbb{E}[\hat{\tau}|\boldsymbol{s}])$ = Estimate of sampling uncertainty, i.e., the variance of the expected total emissions reduction, conditional on the realized sample.
$\mathbb{E}[\mathrm{Var}(\hat{\tau}|\boldsymbol{s})]$ = Estimate of model uncertainty, i.e., the expectation of the conditional variance given the sample.
$\boldsymbol{s}$ = the realized sample, selected using the sample design

For the two-stage design described in Appendix D.1.3, the two variance components in Equation D.12 (model variance and sample variance) can be estimated as shown in Equation D.13.

Equation D.13.

$$\widehat{\mathrm{Var}}(\hat{\tau}) = \widehat{\mathrm{Var}}(\mathbb{E}[\hat{\tau}|\boldsymbol{s}]) + \widehat{\mathbb{E}}[\mathrm{Var}(\hat{\tau}|\boldsymbol{s})]$$
$$= \frac{A^2}{n} s_{\mathrm{sample}}^2 + s_{\mathrm{model}}^2$$

where:

$$s_{\mathrm{sample}}^2 = \frac{1}{(n-1)} \sum_{i=1}^{n} (\hat{y}_i - \hat{\mu})^2$$
$$s_{\mathrm{model}}^2 = \frac{1}{L-1} \sum_{l=1}^{L} (\tilde{\tau}_l - \hat{\tau})^2$$
$$\tilde{\tau}_l = \frac{A}{n} \sum_{i=1}^{n} \left(\frac{1}{m_i} \sum_{j=1}^{m_i} \tilde{y}_{ijl} \right)$$

and

$\hat{\tau}$ = estimate of total GHG emissions reduction for the project (tCO_2e)
$\tilde{\tau}_l$ = total GHG emissions reduction for the l^{th} MC simulation of the project (tCO_2e),
$\hat{y}_i$ = estimate of the areal mean GHG emissions reduction from the samples in field selection i (tCO_2e per acre), estimated as the average over the points and MC simulations: $\hat{y}_i = \frac{1}{m_i}\sum_{j=1}^{m_i}\left(\frac{1}{L}\sum_{l=1}^{L}\tilde{y}_{ijl}\right)$
A = total area of the project (acres)
n = number of field selections
L = number of MC simulations

and the variance of the average GHG emission reduction $\left(\widehat{\mathrm{Var}}(\hat{\mu})\right)$ is estimated by dividing $\widehat{\mathrm{Var}}(\hat{\tau})$ by A^2.

D.2.4 Extensions to other sample designs

Sampling designs can be simple or complex. Examples include simple random sampling, probability proportion to size (see Appendix D.1.3), stratified sampling, multi-stage sampling, or a combination of these methods (see Cochran, 1977 and Särndal et. al., 2003 for more examples). The calculations in Equations D.11-D.13 are for the two-stage sampling design discussed in Appendix D.1.3. Equations D.11-D13 need to be altered for other sampling designs as described in Appendices D.2.4.1 and D.2.4.2 for two other common sampling designs.

D.2.4.1 One-stage SRSWR

In a one-stage simple random sample with replacement (SRSWR) design, points are the primary sampling unit. For example, points may be selected at a constant density across the entire project area. Under this design, the number of points in a given field is a Poisson random variable for sufficiently large sample sizes. Consequently, this design is also called a Poisson sampling design with replacement.

Similar to the two-stage design, the GHG emission reductions are calculated as the difference in GHG emission under baseline and project scenarios as detailed in Equation D.14. Here the index i for fields is not used because fields do not play a role in the sampling process; points continue to be indexed by j, and the number of primary sampling units, n, is now the number of points.

Equation D.14.

GHG emission reductions for one-stage designs in which points are the primary sampling units:

$$\tilde{y}_{jl} = \tilde{z}_{\mathrm{bl},jl} - \tilde{z}_{\mathrm{pr},jl}$$

where:

$\tilde{y}_{jl}$ = Predicted GHG emission reductions for point *j* and MC simulation l (tCO_2e per acre)
$\tilde{z}_{\mathrm{bl},jl}$ = Baseline scenario predicted GHG emissions for point *j*, and MC simulation l (tCO_2e per acre)
$\tilde{z}_{\mathrm{pr},jl}$ = Project scenario predicted GHG emissions for point *j* and MC simulation l (tCO_2e per acre)
j = sample point identifier ($j = 1, \dots, n$)
l = Monte Carlo index ($l = 1, \dots, L$), where L is the total number of MC Simulations

Note: As in Equation D.10, this equation holds for a single source of emissions.

The total and areal mean are estimated as detailed in Equation D.15:

Equation D.15.

$$\hat{\tau} = \frac{A}{nL}\sum_{j=1}^{n}\left(\sum_{l=1}^{L}\tilde{y}_{jl}\right)$$

where:

$\hat{\tau}$ = Monte Carlo estimate (MC mean) of total GHG emissions reductions for the project
$\tilde{y}_{jl}$ = GHG emissions reduction for point j and MC simulation l (tCO_2e per acre)
A = total area of the project (acres)
n = number of points
L = number of MC simulations

and $\hat{\mu} = \hat{\tau}/A$ is the areal average GHG emission reduction (tCO_2e per acre).

The variance is estimated as shown in Equation D.16:

Equation D.16.

$$\widehat{\mathrm{Var}}(\hat{\tau}) = \widehat{\mathrm{Var}}(\mathbb{E}[\hat{\tau}|\boldsymbol{s}]) + \widehat{\mathbb{E}}[\mathrm{Var}(\hat{\tau}|\boldsymbol{s})]$$
$$= \frac{A^2}{n} s^2_{\text{sample}} + s^2_{\text{model}}$$

where:

$$s^2_{\text{sample}} = \frac{1}{(n-1)} \sum_{j=1}^{n} \left(\hat{y}_j - \hat{\mu}\right)^2$$
$$s^2_{\text{model}} = \frac{1}{L-1} \sum_{l=1}^{L} (\tilde{\tau}_l - \hat{\tau})^2$$
$$\tilde{\tau}_l = \frac{A}{n} \sum_{j=1}^{n} \tilde{y}_{jl}$$

and

$\hat{\tau}$ = MC estimate of total GHG emission reductions for the project (tCO_2e)
$\tilde{\tau}_l$ = total GHG emission reductions for the l^{th} MC simulation of the project (tCO_2e)
$\hat{y}_j$ = MC estimate of the areal mean GHG emissions reduction of point *j* (tCO_2e per acre), estimated as $\hat{y}_j = \frac{1}{L}\sum_{l=1}^{L} \tilde{y}_{jl}$
A = total area of the project (acres)
n = number of points
L = number of MC simulations

and the variance of the average GHG emission reduction $\left(\widehat{\mathrm{Var}}(\hat{\mu})\right)$ is estimated by dividing $\widehat{\mathrm{Var}}(\hat{\tau})$ by A^2.

D.2.4.2 Stratified Simple Random Sampling with Replacement

In stratified SRSWR sampling, the population is divided into nonoverlapping sub-populations called strata and samples are drawn independently in each stratum. When strata are homogeneous in their emissions reduction, efficiency can be increased and provide smaller sampling variance. For the SEP project, strata can be formed by grouping land that share similar variables (e.g., Land Resource Region, soil texture, management practices) that might produce similar GHG emissions reduction. Let H be the number of strata and A_h be the total area in acres in stratum $h = 1, \ldots, H$. Then the estimator of the project-wide total is given by Equation D.17:

Equation D.17.

$$\hat{\tau} = \sum_{i=1}^{H} \hat{\tau}_h$$

Where

$$\hat{\tau}_h = \frac{A_h}{n_h L} \sum_{j=1}^{n_h} \left(\sum_{l=1}^{L} \tilde{y}_{hjl} \right)$$

and

A_h = Area of stratum h
n_h = Number of sample points in stratum h
$\tilde{y}_{hjl}$ = GHG emissions reduction for stratum *h,* point j, and MC simulation l (tCO_2e per acre)

and $\hat{\mu} = \hat{\tau}/A$ is the areal average GHG emission reduction (tCO_2e per acre) where A is the total area of the project (acres).

The variance can be estimated as shown in Equation D.18:

Equation D.18.

$$\widehat{\mathrm{Var}}(\hat{\tau}) = \sum_{h=1}^{H} \left\{ \frac{A_h^2}{n_h} s_{\mathrm{sample},h}^2 \right\} + s_{\mathrm{model}}^2$$

where:

$$s_{\mathrm{sample},h}^2 = \frac{1}{(n_h - 1)} \sum_{j=1}^{n} \left(\hat{y}_{hj} - \hat{\mu}_h \right)^2$$

$$s_{\mathrm{model}}^2 = \frac{1}{L-1} \sum_{l=1}^{L} (\tilde{\tau}_l - \hat{\tau})^2$$

$\hat{\tau} = \frac{1}{L} \sum_{l=1}^{L} \tilde{\tau}_l$ (This is equivalent to the calculation in Equation D.17)

$$\tilde{\tau}_l = \sum_{h=1}^{H} \tilde{\tau}_{hl}$$

$$\tilde{\tau}_{hl} = \frac{A_h}{n_h} \sum_{j=1}^{n_h} \tilde{y}_{hjl}$$

and

$\hat{\tau}$ = estimate of total GHG emissions reduction for the project (tCO_2e)
$\tilde{\tau}_l$ = total GHG emissions reduction for the l^{th} MC simulation of the project (tCO_2e)

$\tilde{\tau}_{hl}$ = total GHG emissions reduction in stratum *h* for the l^{th} MC simulation of the project (tCO_2e)
$\tilde{y}_{hjl}$ = GHG emissions reduction for stratum *h,* point j, and MC simulation l (tCO_2e per acre)
$\hat{\mu}_h$ = Monte Carlo estimate (MC mean) of the areal mean GHG emissions reductions in stratum *h* calculated as $\hat{\mu}_h = \hat{\tau}_h / A_h$
$\hat{y}_{hj}$ = MC estimate of the areal mean GHG emissions reduction of point *j* in stratum h (tCO_2e per acre), estimated as $\hat{y}_{hj} = \frac{1}{L}\sum_{l=1}^{L} \tilde{y}_{hjl}$.
A_h = Area of stratum h
n_h = Number of sample points in stratum h
L = Number of MC draws

The variance of the average GHG emission reduction $\left(\widehat{\mathrm{Var}}(\hat{\mu})\right)$ is estimated by dividing $\widehat{\mathrm{Var}}(\hat{\tau})$ by the square of the total area of the project A^2:

$$\widehat{\mathrm{Var}}(\hat{\mu}) = \sum_{h=1}^{H} \left\{ \frac{A_h^2}{A^2 n_h} s_{\mathrm{sample},h}^2 \right\} + \frac{1}{A^2} s_{\mathrm{model}}^2$$

where:

A = total area of the project (acres)

Note that in Equation D.18, the sampling variance can be calculated separately for each stratum and then summed together because the sampled points are selected independently in different strata (see Theorems 5.1 and 5.2 of Cochran (1977, p. 91–92)). In contrast, the model prediction errors might not be independent across strata due to shared calibration parameters, so the estimation of model variance cannot be split across strata.

D.2.5 Monte Carlo Sample Size

The accuracy of the MC estimates depends on the number of MC draws. The MC error (errors due to using a finite number of MC draws) decreases with increasing number of MC draws. According to Gelman et. al. (2014, page 267) the contribution of MC error to MC estimates of standard error is $\sqrt{1 + 1/L}$. For L = 100 independent MC draws MC error would inflate the standard error by only a factor of 1.005, implying that the MC error adds almost nothing to the uncertainty estimate. Gelman et. al. (2014) suggested a choice of L between 100 to 2,000.

D.3 Uncertainty Deduction

The uncertainty of $\widehat{\widehat{ER}}_t$ is captured in its standard error, which is used in Equation D.20 to compute the uncertainty deduction. The calculations in Appendices D.3 and D.4 can be applied to the results of both Appendices D.1 and D.2.

In practice, it is assumed that errors in estimating the various gases and/or sources of emission are independent, so the standard error of $\widehat{\widehat{ER}}_t$ is the square root of the sum of variances across sources of emissions:

Equation D.19.

$$s_{\widehat{ER}_t} = \sqrt{\sum_G s^2_{\widehat{\Delta G}_t}}$$

where:

$s_{\widehat{ER}_t}$	=	Standard error of areal mean emission reduction $(\widehat{ER})$
$s^2_{\widehat{\Delta G}_t}$	=	Estimated variance of areal mean emission reduction from individual gas or source of emissions G (denoted as $\widehat{\mathrm{Var}}(\hat{\mu})$ in Appendix D.2)
G	=	Gas or source of emissions (see Table 5.2 of the SEP)

The standard error in Equations D.19 may be computed by either uncertainty quantification approach 1 (Appendix D.1) or 2 (Appendix D.2), as depicted in Figure D.1.

As discussed in Section 5.2, the 30th percentile of the distribution of estimated emissions reduction is used for crediting. Equation D.20 (a restatement of Equation 5.1) expresses this transformation as a relative deduction, UNC_t:

Equation D.20.

$$UNC_t = \frac{z_{70\%}\ s_{\widehat{ER}_t}}{\widehat{ER}_t}$$

where:

$\widehat{ER}_t$	=	Estimated per-acre average emission reduction across monitoring period t (across all sources of emissions, including emission sources estimated with models and default equations)
$s_{\widehat{ER}_t}$	=	Standard error of areal mean emission reduction $(\widehat{ER})$ (Equation D.19)
$z_{70\%}$	=	z-score of the 70th percentile of a standard normal distribution ≈ 0.5244005127

D.4 References

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Appendix E Examples for Baseline Development

Sections 3.4.1.3 and 5.1 both provide guidance for the determination of the appropriate historical baseline period, crop and management pattern, and project year modeling approach. This appendix seeks to focus in on specific scenarios and explain how the protocol guidance would be applied. In each scenario which employs the matched baseline, the example will also include details on how to shift to the blended baseline at a future date.

Negative numbers are used to identify the historical baseline period, counting backwards from the project start date. Positive numbers are used to represent the cultivation cycles in the project scenario, counting forwards from the project start date through to the end of the crediting period (crediting periods are 10 years, renewable up to two times for a total potential of 30 years of crediting).

The graphics in the examples contained in this appendix are highly simplified and are meant to illustrate only how the baseline modeling threads are to be organized, as well as how outputs are chosen for determining the baseline SOC stock change or GHG flux for a given reporting period. Figure E.1 shows the more detailed flow of how crop data, practice data, SOC measurements, and weather data are used. Each column of model runs represents a continuation of the baseline threads in the current project year. The outputs from each model run become the inputs to the next model run for that baseline thread. These outputs are selected to form the baseline for a given reporting period depending on whether the project is using the matched baseline (years 1 and 2 of the example) or the blended baseline (years 3 and 4 of the example).

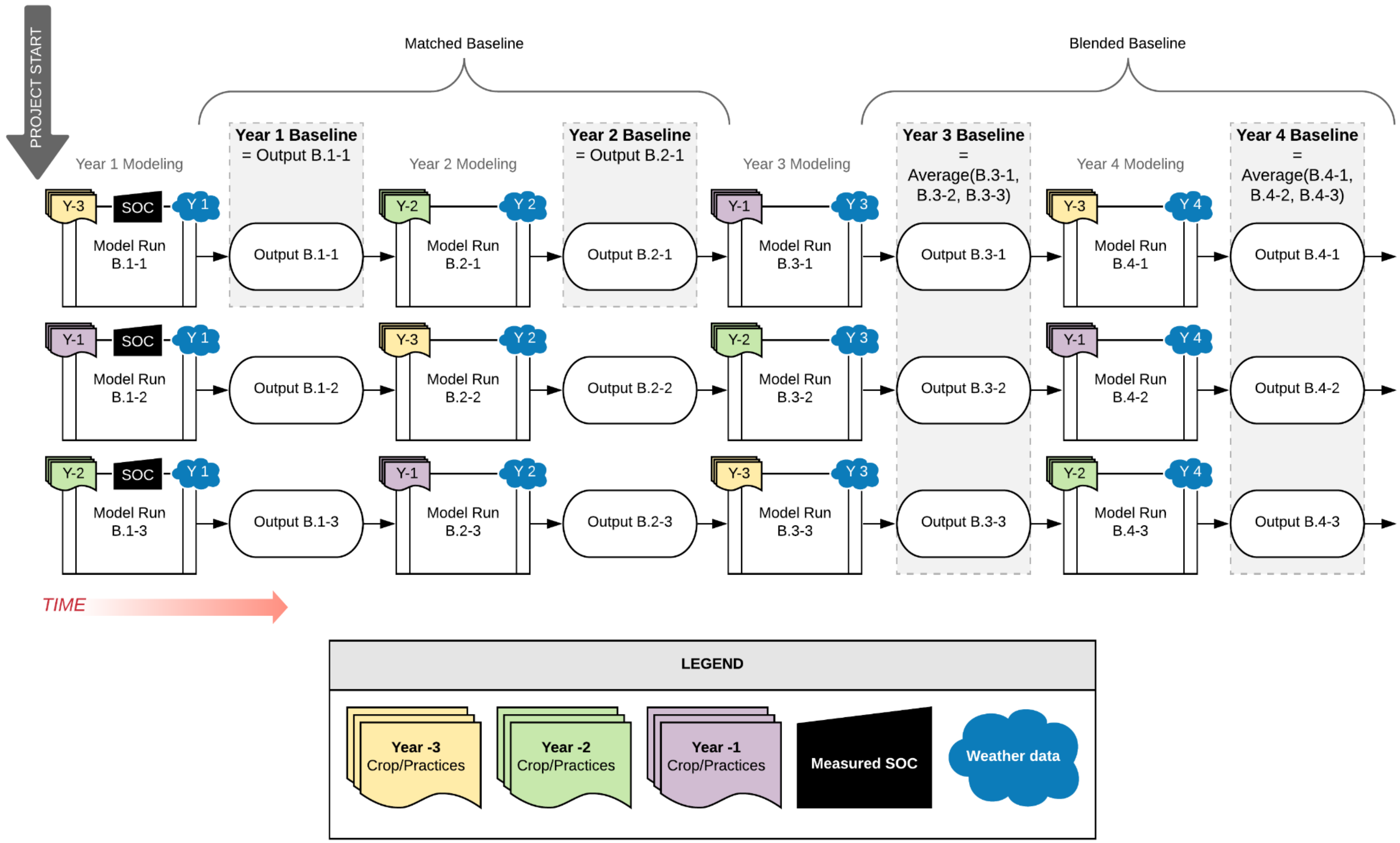


Figure E.1. Conceptual Flow Diagram for Baseline Modeling of a Field With a 3-Year Crop Rotation

The following scenarios are covered in this appendix:

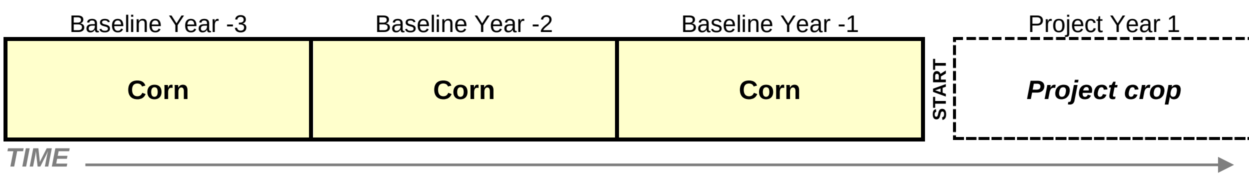
- E.1 Single-Crop System with Consistent Annual Management
- E.2 Two-Year Crop Rotation with Consistent Management by Crop
- E.3 Three-Year Crop Rotation with Consistent Management by Crop
- E.4 Four-Year Crop Rotation with Consistent Management by Crop
- E.5 Five-Year Crop Rotation with Consistent Management by Crop
- E.6 Five-Year Rotation of Two Crops with Consistent Management by Crop
- E.7 Four-Year Crop Rotation with One Repeated Crop
- E.8 Two-Year Crop Rotation with an Unexpected Fallow Year

E.1 Single-Crop System with Consistent Annual Management

In this example, the field grows only corn, and all major management activities are consistent from year to year.

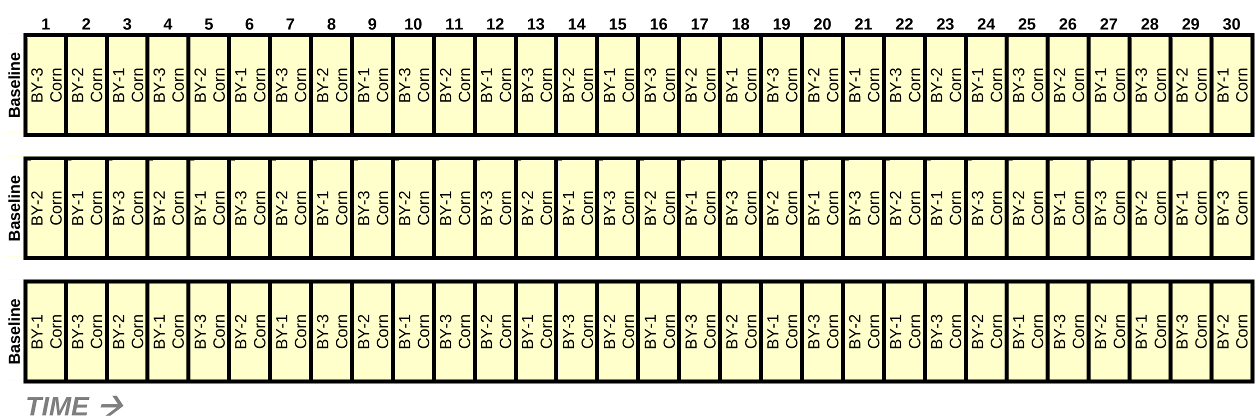
E.1.1 Setting the Historical Baseline Period

Following the guidance in Section 3.4.1.3, this field would be required to, at a minimum, collect crop and management data for the **three** cultivation cycles preceding the project start date.



E.1.2 Setting the Comparison Crop Pattern

Following the guidance in Section 3.4.1.3, the crop comparison pattern is set through the repetition of the entire historical baseline period for a total of 30 years. Note: the reference here to 30 years assumes the project is able to make use of the potential two renewals to its 10-year crediting period, for a total potential 30 years of crediting per field (see Section 0 for guidance on crediting periods). A separate "thread" is created, staggering the same historical rotation one year offset from the previous thread. The total number of baseline threads is equal to the number of years in the historical baseline period.



E.1.3 Modeling the Baseline in Each Project Year

The table below identifies the parameters related to the modeling of the baseline in each year of the crediting period for the project. Note that in this example, since there is only one crop, there is no practical difference between the matched baseline and the blended baseline, regardless of what crop is grown during the project scenario. In other words, a field with a single-year rotation in its baseline historical period will have the same baseline calculation regardless of what changes occur in the project scenario. For each project year the outputs of the colored cells within the same column are averaged together to determine the baseline for that year.

PROJECT YEAR

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
PROJECT SCENARIO															
Project	*Any crop*	*Any crop*	*Any crop*	*Any crop*	*Any crop*	*Any crop*	*Any crop*	*Any crop*	*Any crop*	*Any crop*	*Any crop*	*Any crop*	*Any crop*	*Any crop*	*Any crop*
BASELINE SCENARIO															
Baseline	BY-3 Corn	BY-2 Corn	BY-1 Corn	BY-3 Corn	BY-2 Corn	BY-1 Corn	BY-3 Corn	BY-2 Corn	BY-1 Corn	BY-3 Corn	BY-2 Corn	BY-1 Corn	BY-3 Corn	BY-2 Corn	BY-1 Corn
Baseline	BY-2 Corn	BY-1 Corn	BY-3 Corn	BY-2 Corn	BY-1 Corn	BY-3 Corn	BY-2 Corn	BY-1 Corn	BY-3 Corn	BY-2 Corn	BY-1 Corn	BY-3 Corn	BY-2 Corn	BY-1 Corn	BY-3 Corn
Baseline	BY-1 Corn	BY-3 Corn	BY-2 Corn	BY-1 Corn	BY-3 Corn	BY-2 Corn	BY-1 Corn	BY-3 Corn	BY-2 Corn	BY-1 Corn	BY-3 Corn	BY-2 Corn	BY-1 Corn	BY-3 Corn	BY-2 Corn

	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
PROJECT SCENARIO															
Project	*Any crop*	*Any crop*	*Any crop*	*Any crop*	*Any crop*	*Any crop*	*Any crop*	*Any crop*	*Any crop*	*Any crop*	*Any crop*	*Any crop*	*Any crop*	*Any crop*	*Any crop*
BASELINE SCENARIO															
Baseline	BY-3 Corn	BY-2 Corn	BY-1 Corn	BY-3 Corn	BY-2 Corn	BY-1 Corn	BY-3 Corn	BY-2 Corn	BY-1 Corn	BY-3 Corn	BY-2 Corn	BY-1 Corn	BY-3 Corn	BY-2 Corn	BY-1 Corn
Baseline	BY-2 Corn	BY-1 Corn	BY-3 Corn	BY-2 Corn	BY-1 Corn	BY-3 Corn	BY-2 Corn	BY-1 Corn	BY-3 Corn	BY-2 Corn	BY-1 Corn	BY-3 Corn	BY-2 Corn	BY-1 Corn	BY-3 Corn
Baseline	BY-1 Corn	BY-3 Corn	BY-2 Corn	BY-1 Corn	BY-3 Corn	BY-2 Corn	BY-1 Corn	BY-3 Corn	BY-2 Corn	BY-1 Corn	BY-3 Corn	BY-2 Corn	BY-1 Corn	BY-3 Corn	BY-2 Corn

TIME→

E.2 Two-Year Crop Rotation with Consistent Management by Crop

In this example, the field grows corn and soybeans in alternating years, and all major management activities are consistent from year to year for each crop.

E.2.1 Setting the Historical Baseline Period

Following the guidance in Section 3.4.1.3, this field would be required to, at a minimum, collect crop and management data for the **four** cultivation cycles preceding the project start date.

Baseline Year -4	Baseline Year -3	Baseline Year -2	Baseline Year -1		Project Year 1
Corn	**Soy**	**Corn**	**Soy**	**START**	***Project crop***

TIME→

E.2.2 Setting the Comparison Crop Pattern

Following the guidance in Section 3.4.1.3, the crop comparison pattern is set through the repetition of the entire historical baseline period for a total of 30 years. Note: the reference here to 30 years assumes the project is able to make use of the potential two renewals to its 10-year crediting period, for a total potential 30 years of crediting per field (see Section 0 for guidance on crediting periods). A separate "thread" is created, staggering the same historical rotation one year offset from the previous thread. The total number of baseline threads is equal to the number of years in the historical baseline period.

PROJECT YEAR

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Baseline	BY-4 Corn	BY-3 Soy	BY-2 Corn	BY-1 Soy	BY-4 Corn	BY-3 Soy	BY-2 Corn	BY-1 Soy	BY-4 Corn	BY-3 Soy	BY-2 Corn	BY-1 Soy	BY-4 Corn	BY-3 Soy	BY-2 Corn	BY-1 Soy	BY-4 Corn	BY-3 Soy	BY-2 Corn	BY-1 Soy	BY-4 Corn	BY-3 Soy	BY-2 Corn	BY-1 Soy	BY-4 Corn	BY-3 Soy	BY-2 Corn	BY-1 Soy	BY-4 Corn	BY-3 Soy
Baseline	BY-3 Soy	BY-2 Corn	BY-1 Soy	BY-4 Corn	BY-3 Soy	BY-2 Corn	BY-1 Soy	BY-4 Corn	BY-3 Soy	BY-2 Corn	BY-1 Soy	BY-4 Corn	BY-3 Soy	BY-2 Corn	BY-1 Soy	BY-4 Corn	BY-3 Soy	BY-2 Corn	BY-1 Soy	BY-4 Corn	BY-3 Soy	BY-2 Corn	BY-1 Soy	BY-4 Corn	BY-3 Soy	BY-2 Corn	BY-1 Soy	BY-4 Corn	BY-3 Soy	BY-2 Corn
Baseline	BY-2 Corn	BY-1 Soy	BY-4 Corn	BY-3 Soy	BY-2 Corn	BY-1 Soy	BY-4 Corn	BY-3 Soy	BY-2 Corn	BY-1 Soy	BY-4 Corn	BY-3 Soy	BY-2 Corn	BY-1 Soy	BY-4 Corn	BY-3 Soy	BY-2 Corn	BY-1 Soy	BY-4 Corn	BY-3 Soy	BY-2 Corn	BY-1 Soy	BY-4 Corn	BY-3 Soy	BY-2 Corn	BY-1 Soy	BY-4 Corn	BY-3 Soy	BY-2 Corn	BY-1 Soy
Baseline	BY-1 Soy	BY-4 Corn	BY-3 Soy	BY-2 Corn	BY-1 Soy	BY-4 Corn	BY-3 Soy	BY-2 Corn	BY-1 Soy	BY-4 Corn	BY-3 Soy	BY-2 Corn	BY-1 Soy	BY-4 Corn	BY-3 Soy	BY-2 Corn	BY-1 Soy	BY-4 Corn	BY-3 Soy	BY-2 Corn	BY-1 Soy	BY-4 Corn	BY-3 Soy	BY-2 Corn	BY-1 Soy	BY-4 Corn	BY-3 Soy	BY-2 Corn	BY-1 Soy	BY-4 Corn

TIME→

E.2.3 Modeling the Baseline in Each Project Year

The table below identifies the parameters related to the modeling of the baseline in each year of the crediting period for the project. Note that in this example, in year 10 the project scenario deviates from the comparison crop pattern, meaning that the project is required to switch from the matched baseline to the blended baseline.

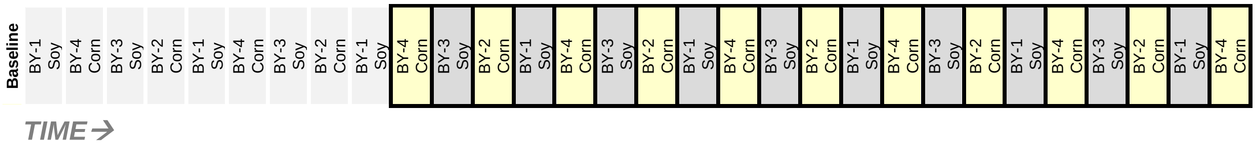
For each project year the outputs of the colored cells within the same column are averaged together to determine the baseline for that year.

PROJECT SCENARIO

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Project	*Corn*	*Soy*	*Corn*	*Soy*	*Corn*	*Soy*	*Corn*	*Soy*	*Corn*	***Alfalfa***	***Soy***	***Corn***	***Alfalfa***	***Soy***	***Corn***	***Alfalfa***	***Soy***	***Corn***	***Alfalfa***	***Soy***	***Corn***	***Alfalfa***	***Soy***	***Corn***	***Alfalfa***	***Soy***	***Corn***	***Alfalfa***	***Soy***	***Corn***

BASELINE SCENARIO

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Baseline	BY-4 Corn	BY-3 Soy	BY-2 Corn	BY-1 Soy	BY-4 Corn	BY-3 Soy	BY-2 Corn	BY-1 Soy	BY-4 Corn	BY-3 Soy	BY-2 Corn	BY-1 Soy	BY-4 Corn	BY-3 Soy	BY-2 Corn	BY-1 Soy	BY-4 Corn	BY-3 Soy	BY-2 Corn	BY-1 Soy	BY-4 Corn	BY-3 Soy	BY-2 Corn	BY-1 Soy	BY-4 Corn	BY-3 Soy	BY-2 Corn	BY-1 Soy	BY-4 Corn	BY-3 Soy
Baseline	BY-3 Soy	BY-2 Corn	BY-1 Soy	BY-4 Corn	BY-3 Soy	BY-2 Corn	BY-1 Soy	BY-4 Corn	BY-3 Soy	BY-2 Corn	BY-1 Soy	BY-4 Corn	BY-3 Soy	BY-2 Corn	BY-1 Soy	BY-4 Corn	BY-3 Soy	BY-2 Corn	BY-1 Soy	BY-4 Corn	BY-3 Soy	BY-2 Corn	BY-1 Soy	BY-4 Corn	BY-3 Soy	BY-2 Corn	BY-1 Soy	BY-4 Corn	BY-3 Soy	BY-2 Corn
Baseline	BY-2 Corn	BY-1 Soy	BY-4 Corn	BY-3 Soy	BY-2 Corn	BY-1 Soy	BY-4 Corn	BY-3 Soy	BY-2 Corn	BY-1 Soy	BY-4 Corn	BY-3 Soy	BY-2 Corn	BY-1 Soy	BY-4 Corn	BY-3 Soy	BY-2 Corn	BY-1 Soy	BY-4 Corn	BY-3 Soy	BY-2 Corn	BY-1 Soy	BY-4 Corn	BY-3 Soy	BY-2 Corn	BY-1 Soy	BY-4 Corn	BY-3 Soy	BY-2 Corn	BY-1 Soy

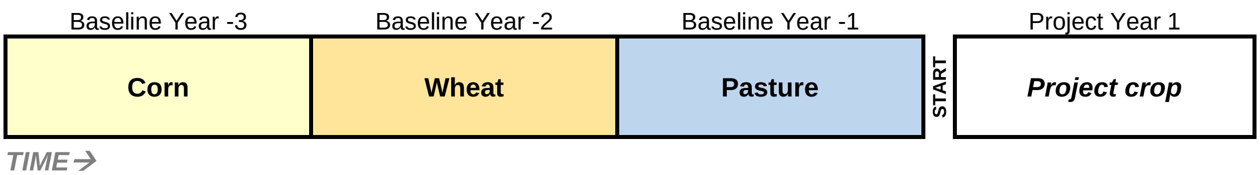


E.3 Three-Year Crop Rotation with Consistent Management by Crop

In this example, the field grows corn and soybeans in alternating years, and all major management activities are consistent from year to year for each crop.

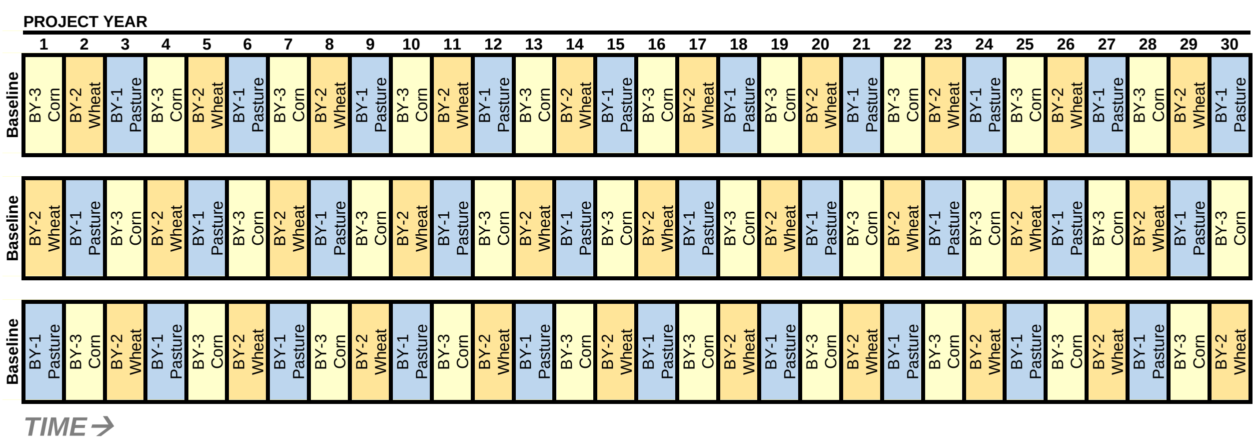
E.3.1 Setting the Historical Baseline Period

Following the guidance in Section 3.4.1.3, this field would be required to, at a minimum, collect crop and management data for the **three** cultivation cycles preceding the project start date.



E.3.2 Setting the Comparison Crop Pattern

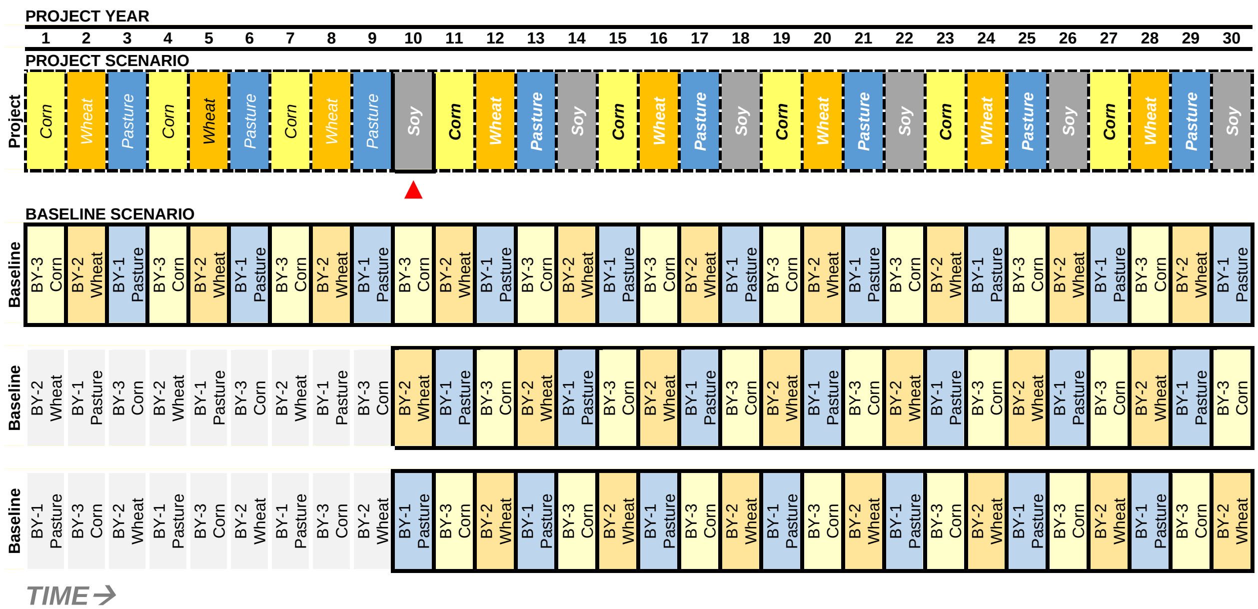
Following the guidance in Section 3.4.1.3, the crop comparison pattern is set through the repetition of the entire historical baseline period for a total of 30 years. Note: the reference here to 30 years assumes the project is able to make use of the potential two renewals to its 10-year crediting period, for a total potential 30 years of crediting per field (see Section 0 for guidance on crediting periods). A separate "thread" is created, staggering the same historical rotation one year offset from the previous thread. The total number of baseline threads is equal to the number of years in the historical baseline period.



E.3.3 Modeling the Baseline in Each Project Year

The table below identifies the parameters related to the modeling of the baseline in each year of the crediting period for the project. Note that in this example, in year 10 the project scenario deviates from the comparison crop pattern, meaning that the project is required to switch from the matched baseline to the blended baseline.

For each project year the outputs of the colored cells within the same column are averaged together to determine the baseline for that year.

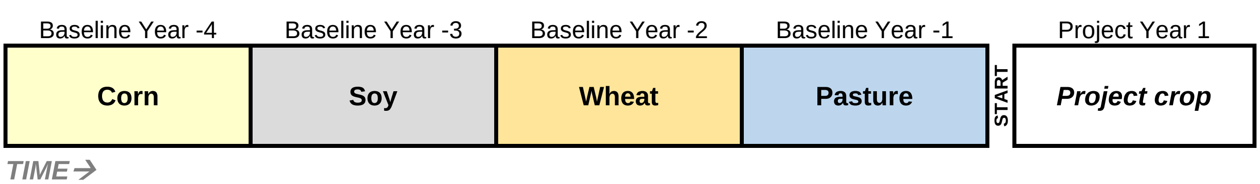


E.4 Four-Year Crop Rotation with Consistent Management by Crop

In this example, the field grows four distinct crops in a repeating annual pattern, and all major management activities are consistent from year to year for each individual crop.

E.4.1 Setting the Historical Baseline Period

Following the guidance in Section 3.4.1.3, this field would be required to, at a minimum, collect crop and management data for the **four** cultivation cycles preceding the project start date.



E.4.2 Setting the Comparison Crop Pattern

Following the guidance in Section 3.4.1.3, the crop comparison pattern is set through the repetition of the entire historical baseline period for a total of 30 years. Note: the reference here to 30 years assumes the project is able to make use of the potential two renewals to its 10-year crediting period, for a total potential 30 years of crediting per field (see Section 0 for guidance on crediting periods). A separate "thread" is created, staggering the same historical rotation one year offset from the previous thread. The total number of baseline threads is equal to the number of years in the historical baseline period.

PROJECT YEAR

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Baseline	BY-4 Corn	BY-3 Soy	BY-2 Wheat	BY-1 Pasture	BY-4 Corn	BY-3 Soy	BY-2 Wheat	BY-1 Pasture	BY-4 Corn	BY-3 Soy	BY-2 Wheat	BY-1 Pasture	BY-4 Corn	BY-3 Soy	BY-2 Wheat	BY-1 Pasture	BY-4 Corn	BY-3 Soy	BY-2 Wheat	BY-1 Pasture	BY-4 Corn	BY-3 Soy	BY-2 Wheat	BY-1 Pasture	BY-4 Corn	BY-3 Soy	BY-2 Wheat	BY-1 Pasture	BY-4 Corn	BY-3 Soy
Baseline	BY-3 Soy	BY-2 Wheat	BY-1 Pasture	BY-4 Corn	BY-3 Soy	BY-2 Wheat	BY-1 Pasture	BY-4 Corn	BY-3 Soy	BY-2 Wheat	BY-1 Pasture	BY-4 Corn	BY-3 Soy	BY-2 Wheat	BY-1 Pasture	BY-4 Corn	BY-3 Soy	BY-2 Wheat	BY-1 Pasture	BY-4 Corn	BY-3 Soy	BY-2 Wheat	BY-1 Pasture	BY-4 Corn	BY-3 Soy	BY-2 Wheat	BY-1 Pasture	BY-4 Corn	BY-3 Soy	BY-2 Wheat
Baseline	BY-2 Wheat	BY-1 Pasture	BY-4 Corn	BY-3 Soy	BY-2 Wheat	BY-1 Pasture	BY-4 Corn	BY-3 Soy	BY-2 Wheat	BY-1 Pasture	BY-4 Corn	BY-3 Soy	BY-2 Wheat	BY-1 Pasture	BY-4 Corn	BY-3 Soy	BY-2 Wheat	BY-1 Pasture	BY-4 Corn	BY-3 Soy	BY-2 Wheat	BY-1 Pasture	BY-4 Corn	BY-3 Soy	BY-2 Wheat	BY-1 Pasture	BY-4 Corn	BY-3 Soy	BY-2 Wheat	BY-1 Pasture
Baseline	BY-1 Pasture	BY-4 Corn	BY-3 Soy	BY-2 Wheat	BY-1 Pasture	BY-4 Corn	BY-3 Soy	BY-2 Wheat	BY-1 Pasture	BY-4 Corn	BY-3 Soy	BY-2 Wheat	BY-1 Pasture	BY-4 Corn	BY-3 Soy	BY-2 Wheat	BY-1 Pasture	BY-4 Corn	BY-3 Soy	BY-2 Wheat	BY-1 Pasture	BY-4 Corn	BY-3 Soy	BY-2 Wheat	BY-1 Pasture	BY-4 Corn	BY-3 Soy	BY-2 Wheat	BY-1 Pasture	BY-4 Corn

TIME→

E.4.3 Modeling the Baseline in Each Project Year

The table below identifies the parameters related to the modeling of the baseline in each year of the crediting period for the project. Note that in this example, in year 10 the project scenario deviates from the comparison crop pattern, meaning that the project is required to switch from the matched baseline to the blended baseline.

For each project year the outputs of the colored cells within the same column are averaged together to determine the baseline for that year.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
PROJECT SCENARIO																														
Project	*Corn*	*Soy*	*Wheat*	*Pasture*	*Corn*	*Soy*	*Wheat*	*Pasture*	*Corn*	***Alfalfa***	**Soy**	***Corn***	***Pasture***	**Soy**	***Corn***	***Wheat***	**Soy**	***Corn***	***Alfalfa***	**Soy**	***Corn***	***Pasture***	**Soy**	***Corn***	***Wheat***	**Soy**	***Corn***	***Alfalfa***	**Soy**	***Corn***
										▲																				
BASELINE SCENARIO																														
Baseline	BY-4 Corn	BY-3 Soy	BY-2 Wheat	BY-1 Pasture	BY-4 Corn	BY-3 Soy	BY-2 Wheat	BY-1 Pasture	BY-4 Corn	BY-3 Soy	BY-2 Wheat	BY-1 Pasture	BY-4 Corn	BY-3 Soy	BY-2 Wheat	BY-1 Pasture	BY-4 Corn	BY-3 Soy	BY-2 Wheat	BY-1 Pasture	BY-4 Corn	BY-3 Soy	BY-2 Wheat	BY-1 Pasture	BY-4 Corn	BY-3 Soy	BY-2 Wheat	BY-1 Pasture	BY-4 Corn	BY-3 Soy
Baseline	BY-3 Soy	BY-2 Wheat	BY-1 Pasture	BY-4 Corn	BY-3 Soy	BY-2 Wheat	BY-1 Pasture	BY-4 Corn	BY-3 Soy	BY-2 Wheat	BY-1 Pasture	BY-4 Corn	BY-3 Soy	BY-2 Wheat	BY-1 Pasture	BY-4 Corn	BY-3 Soy	BY-2 Wheat	BY-1 Pasture	BY-4 Corn	BY-3 Soy	BY-2 Wheat	BY-1 Pasture	BY-4 Corn	BY-3 Soy	BY-2 Wheat	BY-1 Pasture	BY-4 Corn	BY-3 Soy	BY-2 Wheat
Baseline	BY-2 Wheat	BY-1 Pasture	BY-4 Corn	BY-3 Soy	BY-2 Wheat	BY-1 Pasture	BY-4 Corn	BY-3 Soy	BY-2 Wheat	BY-1 Pasture	BY-4 Corn	BY-3 Soy	BY-2 Wheat	BY-1 Pasture	BY-4 Corn	BY-3 Soy	BY-2 Wheat	BY-1 Pasture	BY-4 Corn	BY-3 Soy	BY-2 Wheat	BY-1 Pasture	BY-4 Corn	BY-3 Soy	BY-2 Wheat	BY-1 Pasture	BY-4 Corn	BY-3 Soy	BY-2 Wheat	BY-1 Pasture
Baseline	BY-1 Pasture	BY-4 Corn	BY-3 Soy	BY-2 Wheat	BY-1 Pasture	BY-4 Corn	BY-3 Soy	BY-2 Wheat	BY-1 Pasture	BY-4 Corn	BY-3 Soy	BY-2 Wheat	BY-1 Pasture	BY-4 Corn	BY-3 Soy	BY-2 Wheat	BY-1 Pasture	BY-4 Corn	BY-3 Soy	BY-2 Wheat	BY-1 Pasture	BY-4 Corn	BY-3 Soy	BY-2 Wheat	BY-1 Pasture	BY-4 Corn	BY-3 Soy	BY-2 Wheat	BY-1 Pasture	BY-4 Corn

TIME→

E.5 Five-Year Crop Rotation with Consistent Management by Crop

In this example, the field grows five distinct crops in a repeating annual pattern, and all major management activities are consistent from year to year for each individual crop.

E.5.1 Setting the Historical Baseline Period

Following the guidance in Section 3.4.1.3, this field would be required to, at a minimum, collect crop and management data for the **five** cultivation cycles preceding the project start date.

Baseline Year -5	Baseline Year -4	Baseline Year -3	Baseline Year -2	Baseline Year -1		Project Year 1
Alfalfa	**Corn**	**Soy**	**Wheat**	**Pasture**	**START**	***Project crop***

TIME→

E.5.2 Setting the Comparison Crop Pattern

Following the guidance in Section 3.4.1.3, the crop comparison pattern is set through the repetition of the entire historical baseline period for a total of 30 years. Note: the reference here to 30 years assumes the project is able to make use of the potential two renewals to its 10-year crediting period, for a total potential 30 years of crediting per field (see Section 0 for guidance on crediting periods). A separate "thread" is created, staggering the same historical rotation one year offset from the previous thread. The total number of baseline threads is equal to the number of years in the historical baseline period.

PROJECT YEAR

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Baseline	BY-5 Alfalfa	BY-4 Corn	BY-3 Soy	BY-2 Wheat	BY-1 Pasture	BY-5 Alfalfa	BY-4 Corn	BY-3 Soy	BY-2 Wheat	BY-1 Pasture	BY-5 Alfalfa	BY-4 Corn	BY-3 Soy	BY-2 Wheat	BY-1 Pasture
Baseline	BY-4 Corn	BY-3 Soy	BY-2 Wheat	BY-1 Pasture	BY-5 Alfalfa	BY-4 Corn	BY-3 Soy	BY-2 Wheat	BY-1 Pasture	BY-5 Alfalfa	BY-4 Corn	BY-3 Soy	BY-2 Wheat	BY-1 Pasture	BY-5 Alfalfa
Baseline	BY-3 Soy	BY-2 Wheat	BY-1 Pasture	BY-5 Alfalfa	BY-4 Corn	BY-3 Soy	BY-2 Wheat	BY-1 Pasture	BY-5 Alfalfa	BY-4 Corn	BY-3 Soy	BY-2 Wheat	BY-1 Pasture	BY-5 Alfalfa	BY-4 Corn
Baseline	BY-2 Wheat	BY-1 Pasture	BY-5 Alfalfa	BY-4 Corn	BY-3 Soy	BY-2 Wheat	BY-1 Pasture	BY-5 Alfalfa	BY-4 Corn	BY-3 Soy	BY-2 Wheat	BY-1 Pasture	BY-5 Alfalfa	BY-4 Corn	BY-3 Soy
Baseline	BY-1 Pasture	BY-5 Alfalfa	BY-4 Corn	BY-3 Soy	BY-2 Wheat	BY-1 Pasture	BY-5 Alfalfa	BY-4 Corn	BY-3 Soy	BY-2 Wheat	BY-1 Pasture	BY-5 Alfalfa	BY-4 Corn	BY-3 Soy	BY-2 Wheat

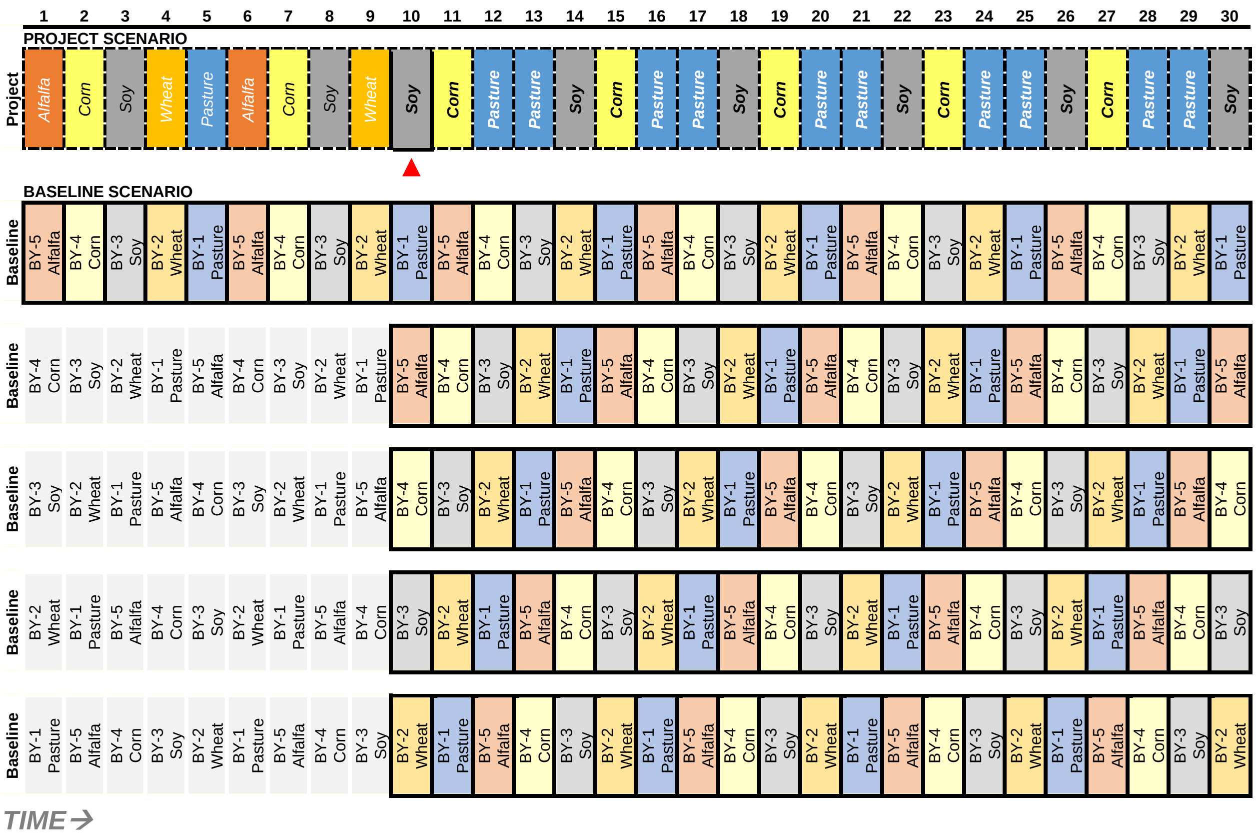
	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Baseline	BY-5 Alfalfa	BY-4 Corn	BY-3 Soy	BY-2 Wheat	BY-1 Pasture	BY-5 Alfalfa	BY-4 Corn	BY-3 Soy	BY-2 Wheat	BY-1 Pasture	BY-5 Alfalfa	BY-4 Corn	BY-3 Soy	BY-2 Wheat	BY-1 Pasture
Baseline	BY-4 Corn	BY-3 Soy	BY-2 Wheat	BY-1 Pasture	BY-5 Alfalfa	BY-4 Corn	BY-3 Soy	BY-2 Wheat	BY-1 Pasture	BY-5 Alfalfa	BY-4 Corn	BY-3 Soy	BY-2 Wheat	BY-1 Pasture	BY-5 Alfalfa
Baseline	BY-3 Soy	BY-2 Wheat	BY-1 Pasture	BY-5 Alfalfa	BY-4 Corn	BY-3 Soy	BY-2 Wheat	BY-1 Pasture	BY-5 Alfalfa	BY-4 Corn	BY-3 Soy	BY-2 Wheat	BY-1 Pasture	BY-5 Alfalfa	BY-4 Corn
Baseline	BY-2 Wheat	BY-1 Pasture	BY-5 Alfalfa	BY-4 Corn	BY-3 Soy	BY-2 Wheat	BY-1 Pasture	BY-5 Alfalfa	BY-4 Corn	BY-3 Soy	BY-2 Wheat	BY-1 Pasture	BY-5 Alfalfa	BY-4 Corn	BY-3 Soy
Baseline	BY-1 Pasture	BY-5 Alfalfa	BY-4 Corn	BY-3 Soy	BY-2 Wheat	BY-1 Pasture	BY-5 Alfalfa	BY-4 Corn	BY-3 Soy	BY-2 Wheat	BY-1 Pasture	BY-5 Alfalfa	BY-4 Corn	BY-3 Soy	BY-2 Wheat

TIME→

E.5.3 Modeling the Baseline in Each Project Year

The table below identifies the parameters related to the modeling of the baseline in each year of the crediting period for the project. Note that in this example, in year 10 the project scenario deviates from the comparison crop pattern, meaning that the project is required to switch from the matched baseline to the blended baseline.

For each project year the outputs of the colored cells within the same column are averaged together to determine the baseline for that year.

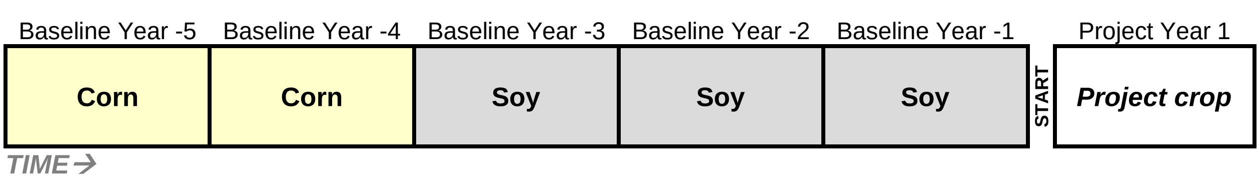


E.6 Five-Year Rotation of Two Crops with Consistent Management by Crop

In this example, the field grows two distinct crops in a repeating five-year pattern, and all major management activities are consistent from year to year for each individual crop.

E.6.1 Setting the Historical Baseline Period

Following the guidance in Section 3.4.1.3, this field would be required to, at a minimum, collect crop and management data for the **five** cultivation cycles preceding the project start date.



E.6.2 Setting the Comparison Crop Pattern

Following the guidance in Section 3.4.1.3, the crop comparison pattern is set through the repetition of the entire historical baseline period for a total of 30 years. Note: the reference here to 30 years assumes the project is able to make use of the potential two renewals to its 10-year crediting period, for a total potential 30 years of crediting per field (see Section 0 for guidance on crediting periods). A separate "thread" is created, staggering the same historical rotation one year offset from the previous thread. The total number of baseline threads is equal to the number of years in the historical baseline period.

PROJECT YEAR

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Baseline	BY-5 Corn	BY-4 Corn	BY-3 Soy	BY-2 Soy	BY-1 Soy	BY-5 Corn	BY-4 Corn	BY-3 Soy	BY-2 Soy	BY-1 Soy	BY-5 Corn	BY-4 Corn	BY-3 Soy	BY-2 Soy	BY-1 Soy	BY-5 Corn	BY-4 Corn	BY-3 Soy	BY-2 Soy	BY-1 Soy	BY-5 Corn	BY-4 Corn	BY-3 Soy	BY-2 Soy	BY-1 Soy	BY-5 Corn	BY-4 Corn	BY-3 Soy	BY-2 Soy	BY-1 Soy
Baseline	BY-4 Corn	BY-3 Soy	BY-2 Soy	BY-1 Soy	BY-5 Corn	BY-4 Corn	BY-3 Soy	BY-2 Soy	BY-1 Soy	BY-5 Corn	BY-4 Corn	BY-3 Soy	BY-2 Soy	BY-1 Soy	BY-5 Corn	BY-4 Corn	BY-3 Soy	BY-2 Soy	BY-1 Soy	BY-5 Corn	BY-4 Corn	BY-3 Soy	BY-2 Soy	BY-1 Soy	BY-5 Corn	BY-4 Corn	BY-3 Soy	BY-2 Soy	BY-1 Soy	BY-5 Corn
Baseline	BY-3 Soy	BY-2 Soy	BY-1 Soy	BY-5 Corn	BY-4 Corn	BY-3 Soy	BY-2 Soy	BY-1 Soy	BY-5 Corn	BY-4 Corn	BY-3 Soy	BY-2 Soy	BY-1 Soy	BY-5 Corn	BY-4 Corn	BY-3 Soy	BY-2 Soy	BY-1 Soy	BY-5 Corn	BY-4 Corn	BY-3 Soy	BY-2 Soy	BY-1 Soy	BY-5 Corn	BY-4 Corn	BY-3 Soy	BY-2 Soy	BY-1 Soy	BY-5 Corn	BY-4 Corn
Baseline	BY-2 Soy	BY-1 Soy	BY-5 Corn	BY-4 Corn	BY-3 Soy	BY-2 Soy	BY-1 Soy	BY-5 Corn	BY-4 Corn	BY-3 Soy	BY-2 Soy	BY-1 Soy	BY-5 Corn	BY-4 Corn	BY-3 Soy	BY-2 Soy	BY-1 Soy	BY-5 Corn	BY-4 Corn	BY-3 Soy	BY-2 Soy	BY-1 Soy	BY-5 Corn	BY-4 Corn	BY-3 Soy	BY-2 Soy	BY-1 Soy	BY-5 Corn	BY-4 Corn	BY-3 Soy
Baseline	BY-1 Soy	BY-5 Corn	BY-4 Corn	BY-3 Soy	BY-2 Soy	BY-1 Soy	BY-5 Corn	BY-4 Corn	BY-3 Soy	BY-2 Soy	BY-1 Soy	BY-5 Corn	BY-4 Corn	BY-3 Soy	BY-2 Soy	BY-1 Soy	BY-5 Corn	BY-4 Corn	BY-3 Soy	BY-2 Soy	BY-1 Soy	BY-5 Corn	BY-4 Corn	BY-3 Soy	BY-2 Soy	BY-1 Soy	BY-5 Corn	BY-4 Corn	BY-3 Soy	BY-2 Soy

TIME→

E.6.3 Modeling the Baseline in Each Project Year

The table below identifies the parameters related to the modeling of the baseline in each year of the crediting period for the project. Note that in this example, in year 10 the project scenario deviates from the comparison crop pattern, meaning that the project is required to switch from the matched baseline to the blended baseline.

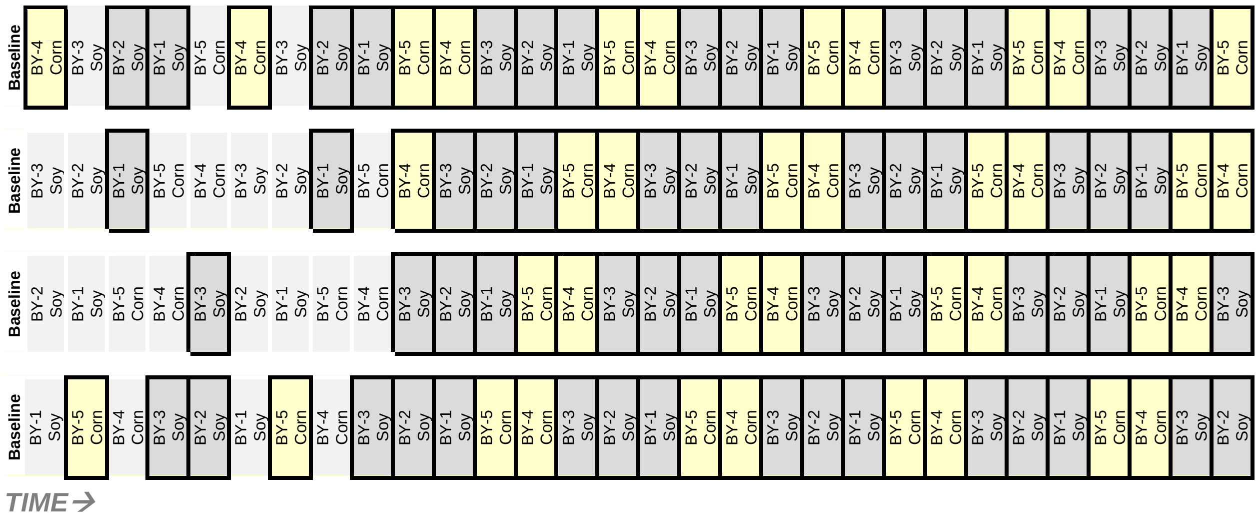
For each project year the outputs of the colored cells within the same column are averaged together to determine the baseline for that year.

PROJECT SCENARIO

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Project	*Corn*	*Corn*	*Soy*	*Soy*	*Soy*	*Corn*	*Corn*	*Soy*	*Soy*	***Pasture***	***Corn***	***Soy***	***Pasture***	***Corn***	***Soy***	***Pasture***	***Corn***	***Soy***	***Pasture***	***Corn***	***Soy***	***Pasture***	***Corn***	***Soy***	***Pasture***	***Corn***	***Soy***	***Pasture***	***Corn***	***Soy***

BASELINE SCENARIO

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Baseline	BY-5 Corn	BY-4 Corn	BY-3 Soy	BY-2 Soy	BY-1 Soy	BY-5 Corn	BY-4 Corn	BY-3 Soy	BY-2 Soy	BY-1 Soy	BY-5 Corn	BY-4 Corn	BY-3 Soy	BY-2 Soy	BY-1 Soy	BY-5 Corn	BY-4 Corn	BY-3 Soy	BY-2 Soy	BY-1 Soy	BY-5 Corn	BY-4 Corn	BY-3 Soy	BY-2 Soy	BY-1 Soy	BY-5 Corn	BY-4 Corn	BY-3 Soy	BY-2 Soy	BY-1 Soy

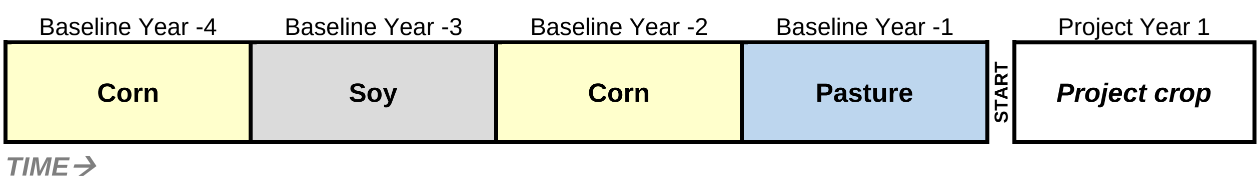


E.7 Four-Year Crop Rotation with One Repeated Crop

In this example, the field grows four distinct crops in a repeating annual pattern, and all major management activities are consistent from year to year for each individual crop.

E.7.1 Setting the Historical Baseline Period

Following the guidance in Section 3.4.1.3, this field would be required to, at a minimum, collect crop and management data for the **four** cultivation cycles preceding the project start date.



E.7.2 Setting the Comparison Crop Pattern

Following the guidance in Section 3.4.1.3, the crop comparison pattern is set through the repetition of the entire historical baseline period for a total of 30 years. Note: the reference here to 30 years assumes the project is able to make use of the potential two renewals to its 10-year crediting period, for a total potential 30 years of crediting per field (see Section 0 for guidance on crediting periods). A separate “thread” is created, staggering the same historical rotation one year offset from the previous thread. The total number of baseline threads is equal to the number of years in the historical baseline period.

PROJECT YEAR

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Baseline	BY-4 Corn	BY-3 Soy	BY-2 Corn	BY-1 Pasture	BY-4 Corn	BY-3 Soy	BY-2 Corn	BY-1 Pasture	BY-4 Corn	BY-3 Soy	BY-2 Corn	BY-1 Pasture	BY-4 Corn	BY-3 Soy	BY-2 Corn	BY-1 Pasture	BY-4 Corn	BY-3 Soy	BY-2 Corn	BY-1 Pasture	BY-4 Corn	BY-3 Soy	BY-2 Corn	BY-1 Pasture	BY-4 Corn	BY-3 Soy	BY-2 Corn	BY-1 Pasture	BY-4 Corn	BY-3 Soy
Baseline	BY-3 Soy	BY-2 Corn	BY-1 Pasture	BY-4 Corn	BY-3 Soy	BY-2 Corn	BY-1 Pasture	BY-4 Corn	BY-3 Soy	BY-2 Corn	BY-1 Pasture	BY-4 Corn	BY-3 Soy	BY-2 Corn	BY-1 Pasture	BY-4 Corn	BY-3 Soy	BY-2 Corn	BY-1 Pasture	BY-4 Corn	BY-3 Soy	BY-2 Corn	BY-1 Pasture	BY-4 Corn	BY-3 Soy	BY-2 Corn	BY-1 Pasture	BY-4 Corn	BY-3 Soy	BY-2 Corn
Baseline	BY-2 Corn	BY-1 Pasture	BY-4 Corn	BY-3 Soy	BY-2 Corn	BY-1 Pasture	BY-4 Corn	BY-3 Soy	BY-2 Corn	BY-1 Pasture	BY-4 Corn	BY-3 Soy	BY-2 Corn	BY-1 Pasture	BY-4 Corn	BY-3 Soy	BY-2 Corn	BY-1 Pasture	BY-4 Corn	BY-3 Soy	BY-2 Corn	BY-1 Pasture	BY-4 Corn	BY-3 Soy	BY-2 Corn	BY-1 Pasture	BY-4 Corn	BY-3 Soy	BY-2 Corn	BY-1 Pasture
Baseline	BY-1 Pasture	BY-4 Corn	BY-3 Soy	BY-2 Corn	BY-1 Pasture	BY-4 Corn	BY-3 Soy	BY-2 Corn	BY-1 Pasture	BY-4 Corn	BY-3 Soy	BY-2 Corn	BY-1 Pasture	BY-4 Corn	BY-3 Soy	BY-2 Corn	BY-1 Pasture	BY-4 Corn	BY-3 Soy	BY-2 Corn	BY-1 Pasture	BY-4 Corn	BY-3 Soy	BY-2 Corn	BY-1 Pasture	BY-4 Corn	BY-3 Soy	BY-2 Corn	BY-1 Pasture	BY-4 Corn

TIME→

E.7.3 Modeling the Baseline in Each Project Year

The table below identifies the parameters related to the modeling of the baseline in each year of the crediting period for the project. Note that in this example, in year 10 the project scenario deviates from the comparison crop pattern, meaning that the project is required to switch from the matched baseline to the blended baseline.

For each project year the outputs of the colored cells within the same column are averaged together to determine the baseline for that year.

PROJECT SCENARIO

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Project	*Corn*	*Soy*	*Corn*	*Pasture*	*Corn*	*Soy*	*Corn*	*Pasture*	*Corn*	*Alfalfa*	*Corn*	*Soy*	*Corn*	*Alfalfa*	*Pasture*	*Corn*	*Soy*	*Corn*	*Alfalfa*	*Pasture*	*Corn*	*Soy*	*Corn*	*Alfalfa*	*Pasture*	*Corn*	*Soy*	*Corn*	*Alfalfa*	*Pasture*

BASELINE SCENARIO

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Baseline	BY-4 Corn	BY-3 Soy	BY-2 Corn	BY-1 Pasture	BY-4 Corn	BY-3 Soy	BY-2 Corn	BY-1 Pasture	BY-4 Corn	BY-3 Soy	BY-2 Corn	BY-1 Pasture	BY-4 Corn	BY-3 Soy	BY-2 Corn	BY-1 Pasture	BY-4 Corn	BY-3 Soy	BY-2 Corn	BY-1 Pasture	BY-4 Corn	BY-3 Soy	BY-2 Corn	BY-1 Pasture	BY-4 Corn	BY-3 Soy	BY-2 Corn	BY-1 Pasture	BY-4 Corn	BY-3 Soy
Baseline	BY-3 Soy	BY-2 Corn	BY-1 Pasture	BY-4 Corn	BY-3 Soy	BY-2 Corn	BY-1 Pasture	BY-4 Corn	BY-3 Soy	BY-2 Corn	BY-1 Pasture	BY-4 Corn	BY-3 Soy	BY-2 Corn	BY-1 Pasture	BY-4 Corn	BY-3 Soy	BY-2 Corn	BY-1 Pasture	BY-4 Corn	BY-3 Soy	BY-2 Corn	BY-1 Pasture	BY-4 Corn	BY-3 Soy	BY-2 Corn	BY-1 Pasture	BY-4 Corn	BY-3 Soy	BY-2 Corn
Baseline	BY-2 Corn	BY-1 Pasture	BY-4 Corn	BY-3 Soy	BY-2 Corn	BY-1 Pasture	BY-4 Corn	BY-3 Soy	BY-2 Corn	BY-1 Pasture	BY-4 Corn	BY-3 Soy	BY-2 Corn	BY-1 Pasture	BY-4 Corn	BY-3 Soy	BY-2 Corn	BY-1 Pasture	BY-4 Corn	BY-3 Soy	BY-2 Corn	BY-1 Pasture	BY-4 Corn	BY-3 Soy	BY-2 Corn	BY-1 Pasture	BY-4 Corn	BY-3 Soy	BY-2 Corn	BY-1 Pasture
Baseline	BY-1 Pasture	BY-4 Corn	BY-3 Soy	BY-2 Corn	BY-1 Pasture	BY-4 Corn	BY-3 Soy	BY-2 Corn	BY-1 Pasture	BY-4 Corn	BY-3 Soy	BY-2 Corn	BY-1 Pasture	BY-4 Corn	BY-3 Soy	BY-2 Corn	BY-1 Pasture	BY-4 Corn	BY-3 Soy	BY-2 Corn	BY-1 Pasture	BY-4 Corn	BY-3 Soy	BY-2 Corn	BY-1 Pasture	BY-4 Corn	BY-3 Soy	BY-2 Corn	BY-1 Pasture	BY-4 Corn

TIME→

E.8 Two-Year Crop Rotation with an Unexpected Fallow Year

In this example, the field grows corn and soybeans in alternating years, with all major management activities are consistent from year to year for each crop. However, there is a fallow year in the historical baseline period, likely due to a “prevent plant” situation, where adverse weather conditions prevented the farmer from planting the crop for that year. In this case, the protocol allows for use of the matched baseline, so long as the project year crop otherwise matches the historical comparison crop pattern.

For fields which were previously left fallow between major crop growing seasons, and in the project scenario are no longer fallow (e.g., planting winter cover crops), this practice change does not affect the rotation as it relates to the determination of the baseline.

E.8.1 Setting the Historical Baseline Period

Following the guidance in Section 3.4.1.3, this field would be required to, at a minimum, collect crop and management data for the **four** cultivation cycles preceding the project start date.

Baseline Year -4	Baseline Year -3	Baseline Year -2	Baseline Year -1		Project Year 1
Corn	**Soy**	**Fallow**	**Soy**	**START**	***Project crop***

TIME→

E.8.2 Setting the Comparison Crop Pattern

Following the guidance in Section 3.4.1.3, the crop comparison pattern is set through the repetition of the entire historical baseline period for a total of 30 years. Note: the reference here to 30 years assumes the project is able to make use of the potential two renewals to its 10-year crediting period, for a total potential 30 years of crediting per field (see Section 0 for guidance on crediting periods). A separate “thread” is created, staggering the same historical rotation one year offset from the previous thread. The total number of baseline threads is equal to the number of years in the historical baseline period.

PROJECT YEAR

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Baseline	BY-4 Corn	BY-3 Soy	BY-2 Fallow	BY-1 Soy	BY-4 Corn	BY-3 Soy	BY-2 Fallow	BY-1 Soy	BY-4 Corn	BY-3 Soy	BY-2 Fallow	BY-1 Soy	BY-4 Corn	BY-3 Soy	BY-2 Fallow	BY-1 Soy	BY-4 Corn	BY-3 Soy	BY-2 Fallow	BY-1 Soy	BY-4 Corn	BY-3 Soy	BY-2 Fallow	BY-1 Soy	BY-4 Corn	BY-3 Soy	BY-2 Fallow	BY-1 Soy	BY-4 Corn	BY-3 Soy
Baseline	BY-3 Soy	BY-2 Fallow	BY-1 Soy	BY-4 Corn	BY-3 Soy	BY-2 Fallow	BY-1 Soy	BY-4 Corn	BY-3 Soy	BY-2 Fallow	BY-1 Soy	BY-4 Corn	BY-3 Soy	BY-2 Fallow	BY-1 Soy	BY-4 Corn	BY-3 Soy	BY-2 Fallow	BY-1 Soy	BY-4 Corn	BY-3 Soy	BY-2 Fallow	BY-1 Soy	BY-4 Corn	BY-3 Soy	BY-2 Fallow	BY-1 Soy	BY-4 Corn	BY-3 Soy	BY-2 Fallow
Baseline	BY-2 Fallow	BY-1 Soy	BY-4 Corn	BY-3 Soy	BY-2 Fallow	BY-1 Soy	BY-4 Corn	BY-3 Soy	BY-2 Fallow	BY-1 Soy	BY-4 Corn	BY-3 Soy	BY-2 Fallow	BY-1 Soy	BY-4 Corn	BY-3 Soy	BY-2 Fallow	BY-1 Soy	BY-4 Corn	BY-3 Soy	BY-2 Fallow	BY-1 Soy	BY-4 Corn	BY-3 Soy	BY-2 Fallow	BY-1 Soy	BY-4 Corn	BY-3 Soy	BY-2 Fallow	BY-1 Soy
Baseline	BY-1 Soy	BY-4 Corn	BY-3 Soy	BY-2 Fallow	BY-1 Soy	BY-4 Corn	BY-3 Soy	BY-2 Fallow	BY-1 Soy	BY-4 Corn	BY-3 Soy	BY-2 Fallow	BY-1 Soy	BY-4 Corn	BY-3 Soy	BY-2 Fallow	BY-1 Soy	BY-4 Corn	BY-3 Soy	BY-2 Fallow	BY-1 Soy	BY-4 Corn	BY-3 Soy	BY-2 Fallow	BY-1 Soy	BY-4 Corn	BY-3 Soy	BY-2 Fallow	BY-1 Soy	BY-4 Corn

TIME→

E.8.3 Modeling the Baseline in Each Project Year

The table below identifies the parameters related to the modeling of the baseline in each year of the crediting period for the project. Since the baseline fallow year occurred in a year that would have otherwise been a corn year, the fallow year is treated as a corn year for the purposes of the matched baseline. Note that in this example, in year 10 the project scenario deviates from the comparison crop pattern, meaning that the project is required to switch from the matched baseline to the blended baseline. Note that in this example, in the first year of the project there is a cover crop in response to another weather-related prevent plant scenario. Rather than leave the field fallow, as was done in the baseline, the project has elected to plant a cover crop. Per the guidance in Section 3.4.1.3, this does not affect the application of the matched baseline.

For each project year the outputs of the colored cells within the same column are averaged together to determine the baseline for that year.

PROJECT SCENARIO

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Project	*Cover crop*	*Soy*	*Corn*	*Soy*	*Corn*	*Soy*	*Corn*	*Soy*	*Corn*	***Alfalfa***	***Soy***	***Corn***	***Alfalfa***	***Soy***	***Corn***	***Alfalfa***	***Soy***	***Corn***	***Alfalfa***	***Soy***	***Corn***	***Alfalfa***	***Soy***	***Corn***	***Alfalfa***	***Soy***	***Corn***	***Alfalfa***	***Soy***	***Corn***

BASELINE SCENARIO

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Baseline	BY-4 Corn	BY-3 Soy	BY-2 Fallow	BY-1 Soy	BY-4 Corn	BY-3 Soy	BY-2 Fallow	BY-1 Soy	BY-4 Corn	BY-3 Soy	BY-2 Fallow	BY-1 Soy	BY-4 Corn	BY-3 Soy	BY-2 Fallow	BY-1 Soy	BY-4 Corn	BY-3 Soy	BY-2 Fallow	BY-1 Soy	BY-4 Corn	BY-3 Soy	BY-2 Fallow	BY-1 Soy	BY-4 Corn	BY-3 Soy	BY-2 Fallow	BY-1 Soy	BY-4 Corn	BY-3 Soy
Baseline	BY-3 Soy	BY-2 Fallow	BY-1 Soy	BY-4 Corn	BY-3 Soy	BY-2 Fallow	BY-1 Soy	BY-4 Corn	BY-3 Soy	BY-2 Fallow	BY-1 Soy	BY-4 Corn	BY-3 Soy	BY-2 Fallow	BY-1 Soy	BY-4 Corn	BY-3 Soy	BY-2 Fallow	BY-1 Soy	BY-4 Corn	BY-3 Soy	BY-2 Fallow	BY-1 Soy	BY-4 Corn	BY-3 Soy	BY-2 Fallow	BY-1 Soy	BY-4 Corn	BY-3 Soy	BY-2 Fallow
Baseline	BY-2 Fallow	BY-1 Soy	BY-4 Corn	BY-3 Soy	BY-2 Fallow	BY-1 Soy	BY-4 Corn	BY-3 Soy	BY-2 Fallow	BY-1 Soy	BY-4 Corn	BY-3 Soy	BY-2 Fallow	BY-1 Soy	BY-4 Corn	BY-3 Soy	BY-2 Fallow	BY-1 Soy	BY-4 Corn	BY-3 Soy	BY-2 Fallow	BY-1 Soy	BY-4 Corn	BY-3 Soy	BY-2 Fallow	BY-1 Soy	BY-4 Corn	BY-3 Soy	BY-2 Fallow	BY-1 Soy
Baseline	BY-1 Soy	BY-4 Corn	BY-3 Soy	BY-2 Fallow	BY-1 Soy	BY-4 Corn	BY-3 Soy	BY-2 Fallow	BY-1 Soy	BY-4 Corn	BY-3 Soy	BY-2 Fallow	BY-1 Soy	BY-4 Corn	BY-3 Soy	BY-2 Fallow	BY-1 Soy	BY-4 Corn	BY-3 Soy	BY-2 Fallow	BY-1 Soy	BY-4 Corn	BY-3 Soy	BY-2 Fallow	BY-1 Soy	BY-4 Corn	BY-3 Soy	BY-2 Fallow	BY-1 Soy	BY-4 Corn

TIME→