CLIMATE ACTION RESERVE

Rice Cultivation Project Protocol

Reducing Methane Emissions from Rice Cultivation

PUBLIC DRAFT

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Abbreviations and Acronyms

CDM	Clean Development Mechanism
CH_4	Methane
CO_2	Carbon dioxide
CRT	Climate Reserve Tonne
EPA	Environmental Protection Agency
GHG	Greenhouse gas
ISO	International Organization for Standardization
lb	Pound
MT	Metric ton (or tonne)
N_2O	Nitrous oxide
RC	Rice cultivation
Reserve	Climate Action Reserve
SSRs	Sources, sinks, and reservoirs
UNFCCC	United Nations Framework Convention on Climate Change

1 Introduction

The Climate Action Reserve (Reserve) Rice Cultivation Project Protocol (RCPP) provides guidance to account for, report, and verify greenhouse gas (GHG) emission reductions associated with the implementation of rice cultivation practice changes that result in a decrease in methane emissions to the atmosphere.

The Climate Action Reserve is a national offsets program working to ensure integrity, transparency, and financial value in the U.S. carbon market. It does this by establishing regulatory-quality standards for the development, quantification and verification of GHG emissions reduction projects in North America; issuing carbon offset credits known as Climate Reserve Tonnes (CRT) generated from such projects; and tracking the transaction of credits over time in a transparent, publicly-accessible system. Adherence to the Reserve's high standards ensures that emission reductions associated with projects are real, permanent and additional, thereby instilling confidence in the environmental benefit, credibility and efficiency of the U.S. carbon market.

Project developers and aggregators that initiate rice cultivation (RC) 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 aggregates receive annual, independent verification by ISO-accredited and Reserve-approved verification bodies. Guidance for verification bodies to verify reductions is provided in the Reserve Verification Program Manual and Section 8 of this protocol.

This protocol is designed to ensure the complete, consistent, transparent, accurate, and conservative quantification and verification of GHG emission reductions associated with a rice cultivation (RC) project.

2 The GHG Reduction Project

2.1 Background

Methane (CH_4), a potent greenhouse gas (GHG), can be formed as a by-product of microbial respiration reactions that occur when organic materials decompose in the absence of oxygen (i.e. under anaerobic conditions). In the United States, rice is almost exclusively grown on flooded fields.[1] When fields are flooded during rice cultivation, oxygen retained in soil pores is rapidly depleted by aerobic decomposition of organic plant residues in the soil, and the soil environment becomes anaerobic. Organic matter continues to decompose under anaerobic conditions, resulting in formation of methane gas. While as much as 60 to 90 percent of the CH_4 produced by the anaerobic microbes is oxidized within the soil by aerobic microbes, remaining un-oxidized CH_4 is transported from the soil to the atmosphere via diffusive transport through the rice plants and the floodwaters.[1]

The annual quantity of methane emitted to the atmosphere at a given rice field will depend on numerous factors related primarily to the water and plant residue management systems in place. Other contributing factors include fertilization practices (using organic vs. synthetic fertilizer), soil properties (type, temperature), rice variety, and other cultivation practices (i.e. tillage, seeding, and weeding practices).

According to the U.S. EPA, rice is currently cultivated in eight states (AR, CA, FL, LA, MS, MO, OK, TX), and rice cultivation is considered to be a relatively small source of CH_4 emissions in the U.S., with total 2009 emissions estimated to be 7.3 MMT CO_2e.[1] Nevertheless, opportunity exists to reduce the methane generated by rice cultivation through implementation of cultivation practice changes related to water and residue management. Management practice changes that decrease the amount of organic matter deposited in the soil, or decrease the amount of time a field is flooded, will typically reduce GHG emissions compared to baseline management practices.

Due to the complexities involved with accurately quantifying GHG emissions resulting from the biogeochemical interactions that occur in cropped rice field systems, this protocol relies on the application of the Denitrification – Decomposition (DNDC) biogeochemical process model for quantification of baseline and project GHG emissions to quantify associated emission reductions. Because of the significant geographic variability related to soil types, climate, and cultivation management practices, the DNDC model must be properly validated for the geographic area and for all relevant cultivation practices in order for the model to perform with an acceptable degree of certainty. Therefore, this protocol will apply only to the regions and practices for which the DNDC model has been explicitly validated with measured data. While this version of the RCPP is valid only in specified rice growing regions, the Reserve expects to periodically update the protocol to expand the geographic scope to include other U.S. rice growing regions as data and model calibration results become available. Currently, however, this protocol only applies to RC projects located in the California Sacramento Valley (CSV) rice-growing region.

[1] U.S. EPA Inventory of U.S. Greenhouse Gas Emissions and Sinks.

Background on Rice Cultivation Techniques

In the US there are three dominant flooding systems for rice cultivation: continuous flood, pinpoint flood, and delayed flood.

- Continuous flood: In a continuous flood system fields are flooded prior to seeding. Once the flood is established, pre-germinated or sprouted seeds are sown (typically by aircraft) into a flooded field. These fields are then maintained in a flooded state until they are drained just before harvest.
- Pinpoint flood: In the pinpoint flood system, pre-germinated seeds are sown into floodwater. The field is drained after seeding for several days to allow the roots to establish or "peg" in the soil. This drain period varies based on soil conditions and weather, but typically lasts for 3-5 days to enable the roots to establish. During this drain period oxygen can permeate back into the soil. Once the rice seeds have pegged into the soil, the fields are re-flooded and maintained in flooded conditions until just before harvest.
- Delayed flood: In a delayed flood system fields are either dry seeded and irrigated for germination or water seeded using pre-germinated seeds that are sown directly into a flooded fields after which the fields are immediately drained. The fields are then kept drained for three to four weeks while the rice canopy is established. Once the canopy is established then the fields are flooded and remained flooded until the typical pre-harvest drain.

Producer's decisions regarding which seeding method to use are targeted at selecting the method that will result in proper seedling emergence and lead to a uniform canopy. Seeding methods depend on soil type, weather conditions, and producer preferences. Differences in seeding methods for rice production relate to (a) dry versus water seeded, (b) drill seeding versus broadcast and (c) use of stale seedbed or conventional seedbed.

- Water seeding: Water seeding describes sowing of dry or soaked seed into a flooded field. It is usually implemented for any or all of the following reasons: red rice control, wet planting season, planting efficiency and earlier crop maturity.
- Dry seeding: Dry seeding simply describes sowing seed into a dry seedbed by drilling or broadcasting. This method usually offers more flexibility in planting but may require more time to do so. This system is also weather dependent.

California Rice Cultivation Practices

In California's Sacramento Valley (CSV) rice growing region (see figure below), continuous flood is the dominant water management technique.[2] Fields are typically flooded to a depth of 4-5 inches just prior to aerial seeding. While deeper flooding reduces weed pressures, it also can lead to poor stand establishment. Once the rice stand is established and the panicle initiation has occurred, many growers will increase the depth of the flood water to 8 inches. This helps with further weed control and protects the rice from cool nighttime temperatures that can lead to reduced yields. Occasionally, several weeks after seeding, fields are drained for one day to apply herbicide for weed control. This drain is short lived and does not lead to drying of the soil surface and does not affect CH_4 emissions. Prior to harvest, water is drained from fields to allow fields to dry, as harvesting equipment cannot function as well on wet soil. The timing of pre-harvest field draining varies from field to field, and can influence total yields. The University of California Cooperative Extension (UCCE) recommends growers drain their fields when the

[2] Correspondence with P. Buttner (CalRice).

panicles are 100% "fully tipped and golden," although fields are often drained earlier to due to other contributing factors such as soil type (soils with high clay content require longer time for drying), and weather.

A continuous flooding and water seeded regime is estimated to be used on over 96% of the acreage in California.[3] A small fraction of the rice acreage is dry seeded in California. The flood for dry seeded rice starts approximately 25-30 days after seeding. During this period, fields are periodically irrigated to promote germination and stand establishment.

Rice straw can have a significant impact on greenhouse gas emissions. Timing of straw amendment/incorporation can impact greenhouse gas emissions by altering the timing and availability of substrate (dissolved organic carbon (DOC)) released from the fresh straw to methanogens in the soil. The timing of the residue incorporation relative to the flooding period will impact total methane production, as will the availability of rice straw on the field. Rice straw incorporation is currently the dominant management practice in California.

Burning of rice straw was the dominant management practice in CA until 1991. Following the 1991 Rice Straw Burning Reduction Act, burning of rice straw decreased dramatically on an annual basis. By the 2001 growing season burning of rice straw was permitted for disease control only with a cap of 25 percent of total rice acreage in the state burned annually. Currently, burning occurs on only 10-12 percent of rice acreage in California.[4] Some growers bale rice straw for off field uses. The current estimate for baling adoption in California is 2-6% of CA rice acres per year[5]. This obviously fluctuates slightly with various straw markets. Baling does not remove all of the rice straw following harvest. Due to operational constraints and the market for straw, baling typically removes between one and two tons of rice straw per acre, out of an average of ~ 3 tons of rice straw available per acre. Of the straw that is baled, much of the straw is sold to end-users, while the straw that goes un-used is typically left on-site. Presently, the majority of rice straw is sold for dairy heifer and beef cattle high roughage feed (estimated to be 75-85%), with some straw used for erosion control (15-25%), and very little sold for building construction. The straw that is baled and left on-site is typically composted in large static piles.

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[3] Based on communication with P. Buttner (CalRice), R. Mutters and L. Espino (University of California Cooperative Extension)
[4] Communication with Paul Buttner.
[5] Based on communication with P. Buttner (CalRice), R. Mutters, L. Espino, and G Nader (University of California Cooperative Extension)

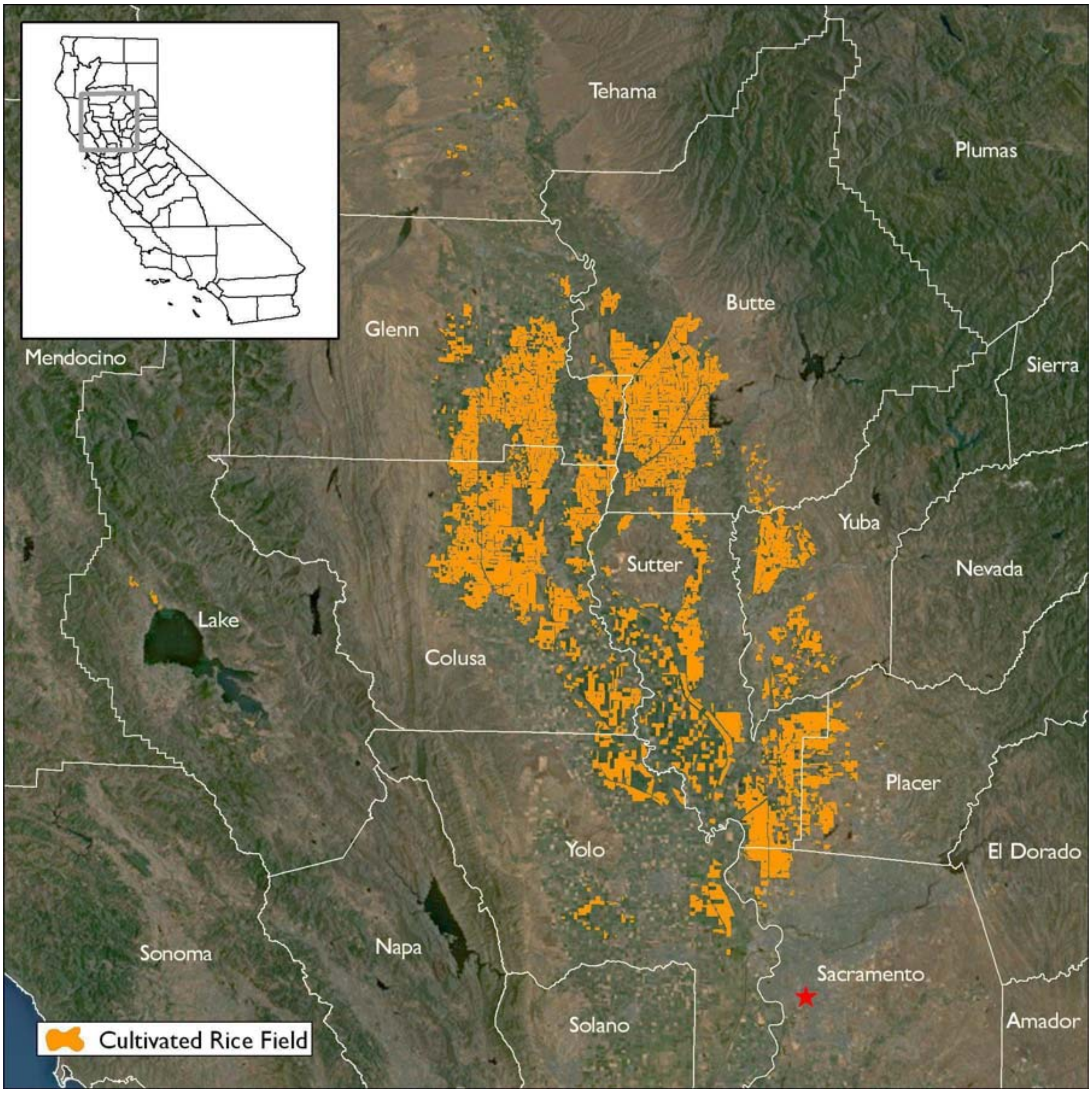

Figure 2.1. California Sacramento Valley Rice Growing Region

2.2 Project Definition

For the purpose of this protocol, a GHG reduction project ("project") is defined as the adoption and maintenance of one or more of the approved rice cultivation project activities[6] that reduce methane (CH_4) emissions. Specific project activities must be adopted and maintained on individual rice fields, with at least one approved project activity implemented on each individual field. Approved rice cultivation project activities must be implemented on at least five individual fields combined into a single project area, also known as the "project aggregate." Physical boundaries for individual fields must be defined according to the requirements in Section 2.2.1.

[6] Note that a project is defined by the adoption of management changes, however GHG reductions are quantified based on actual project performance in terms of reduced CH_4 emissions.

The project aggregate does not need to be comprised of contiguous fields, and can encompass fields located on one farming operation or distributed amongst different farms and/or producers.

Individual participating fields should be submitted to the Reserve as part of a Project Aggregate, according to the rules provided in Section 7. Under this protocol, a project comprised of a single field implementing the approved practice changes may not be submitted to the Reserve unless it joins a Project Aggregate. Aggregation of multiple participating fields is required by this protocol as a means of reducing modeling and quantification uncertainty, but will have the additional benefit of alleviating transaction costs associated with implementation, verification, and registration of RC projects by enabling economies of scale and supporting the marketing of offset credits at volume.

Practice changes described in Table 2.1 below are the approved project activities (by geographic scope).

Table 2.1. Approved Project Activities

Project Activity	Description	Geographic Scope
Dry seeding (DS) with delayed flood	Adoption of a dry seeding method that involves sowing of dry seeds into dry or moist, [illegible] puddled soil, with field flooding delayed until rice stand is established (typically 25-30 days after seeding). Dry seeding can be performed by spreading seeds onto the soil surface and transferring soil on top of the seeds or by drilling seeds into a prepared seedbed, a practice known as “drill seeding.” Regardless of the dry seeding method utilized, the methane reductions occur due to the subsequent delay in flooding of the dry seeded field.	California
Post-harvest rice straw removal and baling (Baling)	After harvest, rice straw residue is traditionally left on agricultural fields and incorporated into soil, however; rice straw can be removed by baling. Doing so reduces the net soil degradable organic carbon (DOC), and therefore decreases methane production from anaerobic decay over the winter season. Baled straw can be sold even though the market is currently small. In California, rice straw can be used for erosion control, animal bedding or as an alternative feed for cow and calf producers[7]	California

2.2.1 Defining Field Boundaries

For the purposes of this protocol, an individual rice field must be defined by the following criteria:

1. The field must be under the direct management control of a single rice producer.
2. The field must be contiguous.
3. Water management within the field boundary must be relatively homogenous. This is defined as having a flood up duration for all checks in the field of less than 96 hours from start to finish (4 acre-inches per acre or more). This can be documented using field sizes and pumping rates.

[7] DANR, publication 8425.

4. Fertilizer management must be relatively homogenous. This criterion is met when application rates across the field do not vary by more than 15% of the average application rate for the entire field. For each application, fertilizer must be applied on the same day with the same type of fertilizer.
5. The field must have at least 5 years of yield data available for DNDC model calibration.

Soil input parameters necessary for DNDC model calibration and emissions modeling must be determined for each field through use of soil sampling, or use of the USDA NRCS SSURGO soil survey data.[8] See Section 6.1 for soil input data collection requirements.

2.3 Project Aggregates

Projects made up of multiple fields are considered project aggregates. Because aggregation is required under this protocol, projects will be referred to hereafter as 'Project Aggregates.' Project Aggregates may encompass fields on single or multiple farming operations. At a minimum, the Project Aggregate must be comprised of at least five individual fields combined into a single project area. There is no lower limit on the total number of rice acres enrolled in a project aggregate, assuming each individual field meets the requirements of Section 2.2.1. Under this protocol, a project comprised of a single field implementing the approved practice changes may not be submitted to the Reserve unless it joins a Project Aggregate.

There is no upper limit on the total number of fields or acres enrolled in a Project Aggregate. There is also no upper limit on the number of landowners or land tenants whose fields are enrolled in a project aggregate. However, there are limits on how large a single field may be in relation to the total combined acreage in a project aggregate, as defined by Table 2.2 below.

Table 2.2. Maximum Field Size, as a Percent of Aggregate Acreage

Aggregate Size (in acres)	Maximum Acreage of a Single Field (% of Aggregate Acreage)
Up to 1000	33%
1001-5000	25%
5001-10000	15%
10001 +	7.5%

Should the number of fields in an aggregate drop below the minimum number of 5 fields due to fields leaving the aggregate, the aggregate can continue reporting reductions to the reserve for the remaining fields for the remainder of the current reporting period, however the aggregate must use the appropriate discount for modeling structural uncertainty (Section 5.1.7). The aggregate must add additional fields to achieve the minimum number of allowable fields within a period of 12 months from the last day of the reporting period in which the aggregate had fewer than 5 fields.

2.3.1 The Project Developer/Aggregator and Project Participants

The project developer is an entity that has an active account in good standing on the Reserve, submits a project for listing and registration with the Reserve, and is ultimately responsible for all project reporting and verification. According to this protocol, project developers are also called Project Aggregators, and can represent one or more project aggregates. Project developers/aggregators may be a corporation or other legally constituted entity, city, county,

[8] See http://soils.usda.gov/survey/geography/ssurgo/.

state agency, agricultural producer, or a combination thereof. An individual rice grower may serve as his/her own Aggregator or as an Aggregator for a group of fields.

The “project participants” are rice growers who elect to enroll in a project aggregate. Project participants must have authority to make cultivation management decisions on their fields that are enrolled in the project aggregate.

Aggregators act as official agents to the Reserve on behalf of project participants and are ultimately responsible for submitting all required forms and complying with the terms of the this protocol. Aggregators manage the flow of ongoing monitoring and verification reports to the Reserve and may engage in other project development activities such as developing monitoring plans, modeling emission reductions, managing data collection and retention etc., or may hire technical contractors to perform these services on their behalf. The scope of aggregator services is negotiated between the project participant and the aggregator and should be reflected in contracts between the project participant and the aggregator.

Aggregators have the authority to develop their own internal monitoring, reporting, and other participation requirements for individual fields as they deem necessary. Aggregators also have the discretion to exclude individual fields enrolled in their aggregate from participating in verification activities for any given reporting period; however, in such cases there can be no CRTs claimed by those fields in the aggregate total.

In all cases, the aggregator must attest to the Reserve that they have exclusive claim to the GHG reductions resulting from all fields in the project aggregate. The aggregator must attest to this requirement by submitting a signed Aggregator’s Attestation of Title[9] form prior to the commencement of verification activities each time the project aggregate is verified (see Section 8).

Though the Aggregator must have exclusive claim to CRTs for the project to complete verification, this protocol does not dictate the terms for how that exclusive title will be established, allowing the aggregator, project participant and land owner (if separate from the project participant) maximum flexibility for the terms of contracts between the respective parties. In the case of project activities taking place on leased fields (e.g. the project participant is not the land owner, but rather a lessee), the Aggregator must notify the land owner with a Letter of Notification of the Intent to Implement a GHG Mitigation Project on the respective field.

As part of verification activities, verifiers shall review contracts and letters of notification as a means of confirming exclusive title to the CRTs. The Reserve will not issue CRTs for GHG reductions that are reported or claimed by entities other than the aggregator.

2.3.2 Entering and Leaving an Aggregate

Individual fields in a project aggregate must remain under continuous management throughout the field’s crediting period (see Section 3.3). Fields may not change aggregates, ownership, tenant occupancy, or management control during a crediting period, unless they meet the criteria and procedures outlined below. Project activities on an individual field may be terminated and the field may elect to leave the Aggregate at any time, however emission reductions must be reported for a complete cultivation cycle, as defined in Section 3.2, and no

[9] The Reserve’s Aggregator’s Attestation of Title form is available at: http://www.climateactionreserve.org/how/projects/register/project-submittal-forms/

CRTs may be claimed for a field that does not participate and report data for a full cultivation cycle.

Fields can change aggregates during a crediting period if and only if:

1. The field changes ownership, tenant occupancy, or management control during the crediting period and the new owner, tenant, or manager has other fields already enrolled with a different aggregator, or
2. The original aggregate is terminated (e.g. goes out of business)

Fields seeking to change aggregates during a crediting period under one of the above allowed circumstances must submit a "Project Aggregate Transfer Form" to the Reserve prior to enrolling in the new aggregate.

After completing the crediting period, a field may elect to enroll in a different aggregate when renewing for an additional crediting period.

A field may change ownership, tenant occupancy, or management control during a crediting period and remain in the project aggregate with uninterrupted crediting, if and only if the following criteria are met:

1. The contract with the Project Aggregator is transferred from the old to the new project participant.
2. The new project participant submits a "Field Management Transfer Form" to the Reserve via their Project Aggregator prior to the beginning of the subsequent cultivation cycle.
3. Implementation of the approved management practices continues without change until the end of the current reporting period.[10]

Where any of the criteria immediately above are not met, a field will forfeit the opportunity to generate CRTs for the cultivation cycle during which the ownership, tenant occupancy, or management control change occurs. The field may re-enter the project aggregate at any time during the remainder of the 5-year crediting period by fulfilling the three requirements above.

[10] See Section 5 for definition of reporting period.

3 Eligibility Rules

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

Eligibility Rule I:	Location	→	*California*
Eligibility Rule II:	Project Start Date	→	*No more than six months prior to project submission*
Eligibility Rule III:	Anaerobic Baseline Conditions	→	*Demonstrate baseline flooded rice cultivation practice*
Eligibility Rule IV:	Other Eligibility Conditions	→	*Demonstrate compliance with other eligibility criteria*
Eligibility Rule IV:	Additionality	→	*Meet performance standard*
		→	*Exceed regulatory requirements*
Eligibility Rule V:	Regulatory Compliance	→	*Compliance with all applicable laws*

3.1 Location

Projects must be located in approved rice growing regions for which the DNDC model has been validated and for which a regional Performance Standard has been developed and included in this protocol. Reductions from projects outside of the approved rice growing regions are not eligible to register with the Reserve at this time.

Rice Growing Regions:

Currently, only the California rice-growing region is approved under this protocol. Therefore, only RC projects located in California are eligible to register reductions with the Reserve. In the future, projects located in other parts of the United States or on U.S. tribal lands may be eligible to register reductions with the Reserve under this protocol as the DNDC model becomes validated in more regions.

High Carbon Content Soils:

Because nitrous oxide (N_2O) emissions are potentially more variable with increased soil carbon content, fields that have soil with organic carbon content greater than 3% in the top 30cm of soil are not eligible at this time. The organic carbon content of the field shall be determined by soil sampling or SSURGO data in accordance with Section 6.2.1.

3.2 Project Start Date

In order to produce accurate GHG emission modeling results, the DNDC model used for calculating GHG reductions must be run for each annual 'cultivation cycle.' For modeling purposes, a 'cultivation cycle' is defined as the period starting immediately after a rice harvest (in late summer or fall), and ending at the end of the next calendar year's harvest. Therefore, a complete cultivation cycle begins with post-harvest residue management over the fall and winter seasons, continues with field preparation, seeding, and cultivation, and culminates at the end of the rice crop harvest. A complete 'cultivation cycle' may be slightly greater or less than 365 days depending on planting/harvest dates etc.

Each field has a unique start date, defined as the first day of the 'cultivation cycle' during which one or more of the approved project activities is adopted at the field.

To be eligible, a field must join an active or new aggregate and submit to the Reserve before the end of the first cultivation cycle after the start date, unless the field is submitted during the first 12 months following the date of adoption of this protocol by the Reserve board (the Effective Date).[11] For a period of 12 months from the Effective Date of this protocol (Version 1.0), fields with start dates on or after September 1, 2009 are eligible to register with the Reserve if submitted by December 14, 2012. Fields with start dates prior to September 1, 2009 are not eligible under this protocol. A field is not eligible if the approved practices were previously adopted on the field for any two or more cultivation cycles at any time during the five-year period prior to the field's start date. Fields may always be submitted for listing by the Reserve prior to their start date.

3.3 Crediting Period

The crediting period for fields under this protocol is five years. The crediting period is renewable up to three times (for a potential of 20 years crediting). During the last six months of a field's crediting period, project aggregators may apply for a field's eligibility under a second, third, or fourth crediting period. During a crediting period, project reporting for each field must be continuous, with no gaps between reporting periods. Reporting periods in which a field does not meet the performance standard (see Section 3.6.1) or is not included in the pool of fields potentially selected for verification for any reason still count towards the five-year crediting period. If a project developer wishes to apply for another crediting period, the project must meet the eligibility requirements of the most current version of this protocol, including any updates to the Performance Standard Test (Section 3.5.1).

Crediting periods do not apply to Project Aggregates, only to individual fields within a Project Aggregate.

The Reserve will issue CRTs for GHG reductions quantified and verified according to this protocol for a maximum of four five-year crediting periods after the field's start date. Section 3.5.1 describes requirements for qualifying for a second, third, and fourth crediting period.

3.4 Anaerobic Baseline Conditions

All fields must demonstrate that previous rice cultivation practices resulted in anaerobic conditions. This requirement is met by demonstrating that:

1. Each individual rice field has been under continuous rice cultivation for five years preceding the start of the crediting period, with no more than one fallow season, and

2. Each individual rice field is was flooded for a period of at least 100 days during each growing season, and

[11] Fields are considered submitted when the aggregator has fully completed and filed the appropriate Aggregate Submittal Form, or the New Field Enrollment form.

3. Management records for each individual rice field are available for each of the five years preceding the field's start date. At a minimum, management records must include:
   - Annual rice yields
   - Planting and harvest dates
   - Flooding[12] and draining[13] dates
   - Fertilizer application dates and amounts

3.5 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

3.5.1 The Performance Standard Test

Projects pass the Performance Standard Test by meeting a performance threshold, i.e. a standard of performance applicable to all RC projects, established by this protocol.

For this protocol, the Reserve uses practice-based thresholds, which serve as "best practice standards" for management practices governing methane emissions from rice cultivation. By meeting the performance threshold for a specific management activity, a rice field demonstrates that cultivation management exceeds the regional common practice standard for methane emissions management. Each rice field participating in a project aggregate must pass the Performance Standard Test for each approved project activity that is implemented on the field.

The performance standard research, summarized in Appendix D, reviewed common water management, residue management, and other RC management practices in the approved rice growing region.[14] Based on the performance standard analysis, the Reserve has developed Performance Standard Tests for each approved project activity, as defined in Section 2.2. Table 3.2 below provides the Performance Standard Test for each approved project activity.

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[12] For each field, the flood date shall be equal to the date that the first 'check' began filling
[13] For each field, the drain date shall be equal to the date that the last 'check' began draining
[14] Based on the geographic limitations imposed by data availability, only management data from California rice cropping systems were sufficiently analyzed in the performance standard for this protocol. The Reserve plans to expand the geographic scope of this protocol to other U.S. regions based upon future data availability and successful peer-reviewed DNDC model validation results.

Table 3.1. Approved Project Activities

Region	Approved Project Activity	Performance Standard Test	Justification
CA	Dry seeding (DS)	A rice field passes the Performance Standard Test by implementing a dry seeding technique combined with delayed flooding. Individual fields that employed dry seeding with delayed flood for 2 or more cultivation cycles in the past 5 years prior to the project start date are ineligible.	Research indicates that dry seeding is currently practiced on less than 3% of the CA rice acreage.[15]
	Post-harvest rice straw removal and baling (Baling)	A rice field passes the Performance Standard Test by implementing post-harvest rice straw 'baling.' Individual fields that employed bailing following harvest 2 or more times in the past 5 years prior to the project start date are ineligible.	Research indicates that residue removal (baling) is currently very limited and variable, occurring on an estimated 2-7% of the CA rice acreage. Despite initiatives launched by state agencies and private partnerships, the market for rice straw has not grown as expected.[15]

Although multiple fields are a submitted together under one project aggregate, each field must separately pass the Performance Standard Test in order to be eligible.

3.5.2 The Legal Requirement Test

All projects are subject to a Legal Requirement Test to ensure that the GHG reductions achieved by a project would not otherwise have occurred due to federal, state, or local regulations, or other legally binding mandates. An RC project passes the Legal Requirement Test when there are no laws, statutes, regulations, court orders, environmental mitigation agreements, permitting conditions, binding contractual obligations, or other legally binding mandates (including conservation management plans and deed restrictions) that require the adoption or continued use of any approved project activities on the project rice fields. Should a field initially pass the LRT, the field will be eligible to earn CRTs from project activity for the remainder of the five year crediting period, regardless of changes in legal requirements.

To satisfy the Legal Requirement Test, aggregators must submit a signed Attestation of Voluntary Implementation form[16] on behalf of all project participants in the aggregate prior to the commencement of verification activities each time the project aggregate is verified (see Section 8). Individual project participants who are part of a project aggregate will not be required to attest to the voluntary nature of project activities to the Reserve. However, supporting documentation should be made available to the Verifier during verification, if requested. In addition, the Aggregate-level Monitoring Plans (Section 6) must include procedures that the aggregator will follow to ascertain and demonstrate that all fields in the project aggregate at all times pass the Legal Requirement Test.

[15] See Appendix C for a Summary of Performance Standard Research
[16] Form available at http://www.climateactionreserve.org/how/projects/register/project-submittal-forms/.

As of the Effective Date of this protocol, the Reserve could identify no existing federal, state or local regulations that explicitly obligate rice producers to adopt the project activities approved under this protocol. If any of the approved project activities of an eligible project later become legally required, emission reductions may be reported to the Reserve up until the date that the management practice is required by law to be adopted. If an RC project includes implementation of more than one of the approved rice cultivation management practices and only one of those practices later becomes legally required, emission reductions from that project activity may be reported to the Reserve up until the date it is required by law and the project may continue reporting emission reductions from the project activities that continue to be voluntary.

3.5.3 Ecosystem Services Payment Stacking

When multiple ecosystem services credits or payments are sought for a single activity on a single piece of land, it is referred to as credit stacking or payment stacking, respectively.[17]

As of the Effective Date of this protocol, the Reserve did not identify any ecosystem service markets besides carbon markets that issue credits for the project activities included in this protocol.[18] As such, credit stacking does not need to be addressed by this protocol at this time.

The Environmental Quality Incentives Program (EQIP) is a national program managed at the state-level by the Natural Resources Conservation Service (NRCS) that provides payments for ecosystem services. The NRCS Conservation Practice Standard (CPS) 344A – Residue Management, Seasonal Rice Straw Residue provides technical and financial assistance to farmers to reduce the amount of rice straw residues on their fields through a variety of methods, including baling the rice straw residue.[19]

CSP 344A has primarily been used in California to fund other residue management practices besides baling.[20] Because baling is expensive, uncommon, and generally not already funded by EQIP, the use of EQIP payments to finance baling projects under this protocol is allowable, but only when the project developer simultaneously pursues EQIP funding and project registration on spatially overlapping areas (i.e. a specific field enrolled in the aggregate). For the purposes of this protocol, activities are considered simultaneous if the project developer applies for EQIP funding for baling on a field for the first time within 12 months of project submittal and for the same cultivation cycle.

Note that if a field receives EQIP 344A payments for any activity *other than* baling, those payments are not considered “stacked” for the purposes of this protocol, as the payments were awarded for different activities than those credited by this protocol.

[17] Cooley, David and Lydia Olander, (September 2011), “Stacking Ecosystem Services Payments: Risk and Solutions,” Nicholas Institute for Environmental Policy Solutions, Duke University. NI WP 11-04. Available at: http://nicholasinstitute.duke.edu/ecosystem/land/stacking-ecosystem-services-payments/at_download/paper

[18] The Reserve did identify a Rice Straw Emissions Reductions Crediting program in California; however, credits from the program are not issued for the project activities included in this protocol, but rather for reduced rice straw burning. The Reserve does not consider Project Participants receiving credits under both the California Rice Straw Emissions Reductions and under this protocol to be “stacking credits.”

[19] NRCS Conservation Practice Standard 344A is available on the NRCS Field Officer Technical Guide website: http://efotg.sc.egov.usda.gov//efotg_locator.aspx

[20] Personal communication with NRCS field personnel in California.

Any other type of ecosystem service payment or credit stacking not explicitly permitted by this protocol is disallowed.

3.6 Regulatory Compliance

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

To satisfy this eligibility requirement, the aggregator must submit a signed Attestation of Regulatory Compliance form, on behalf of all enrolled project participants prior to the commencement of verification activities each time the project aggregate is verified. Individual project participants who are part of a project aggregate will not be required to attest to their status of regulatory compliance to the Reserve. However, supporting documentation should be made available to the Verifier during verification, if requested.

In addition, the Aggregate-level Project Monitoring Plan (Section 6) must include procedures that the project developer/aggregator will follow to ascertain and demonstrate that the project at all times passes the Regulatory Compliance Test.

3.6.1 California Rice Straw Burning Regulation

In California, rice producers are required to comply with the Connelly-Areias-Chandler Rice Straw Burning Reduction Act of 1991 and the subsequent regulations of the Conditional Rice Straw Burn Permit Program, which limit the amount of rice straw residue producers may burn in any given year. The 1991 Act required a phase down of rice straw burning in the Sacramento Valley over a ten-year period, starting in 1992. Since September 2001, the Conditional Rice Straw Burn Permit Program has limited rice straw burning to less than 25% of an individual grower’s planted acreage, not to exceed 125,000 acres in the Sacramento Valley Basin. Initially, rice fields were only allowed to be burned for disease control, which required demonstration of the presence of significant levels of disease in order to secure a Conditional Rice Straw Burn Permit (“Burn Permit”). However, after 100% of rice fields were consistently found to have the “significant” level of disease, this requirement was eliminated. Today, rice producers are simply required to secure Burn Permits for up to 25% of their rice acreage.[21]

When project developers in California sign the Attestation of Regulatory Compliance, they are attesting that they are also in compliance with this regulation and that they have secured the appropriate “Conditional Rice Straw Burn Permits” from the Air Resources Board or other appropriate agency. Wherever rice straw burning occurs, the project developer must demonstrate that the amount of burning was within legal limits, if legal limits exist as is the case in California, and that all necessary permits have been secured.

[21] Regulations establishing the Conditional Rice Straw Burning Program can be found in the California Code of Regulations, Title 17, § 80156. More information can also be found on the California Air Resources Board webpage at: http://www.arb.ca.gov/smp/rice/condburn/condburn.htm

Burning of rice straw is assumed to be an activity that will occur occasionally under business as usual as a pest management strategy. As such, whenever burning occurs, project input parameters to the model (see Section 5) should be adjusted, to reflect the correct percentage of rice straw burned in both the baseline and the project. Additionally, it should be noted that rice straw burning is not an approved project activity; though an increase in rice straw burning may reduce methane emissions, it is not an eligible activity under this protocol, even in cases when an increase in rice burning may be permissible by law.

3.6.2 Regulations on Special-Status Species

Regulations exist at the Federal, State, and Local levels to protect threatened and endangered species (i.e. “special-status species”) of wildlife and their habitats. These regulations include the federal and many state-level Endangered Species Acts and the Migratory Bird Treaty Act. As a component of the federal Endangered Species Act, the US Fish and Wildlife Service works with private landowners to develop Habitat Conservation Plans (HCPs) and Safe Harbor Agreements (SHAs). When in effect on a rice field in an aggregate, an HCP or SHA should be considered a legally binding mandate, which must be considered in the verifier’s evaluation of regulatory compliance.

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 rice cultivation (RC) project.[22]

The GHG Assessment Boundary encompasses all the GHG sources, sinks, and reservoirs that may be significantly affected by project activities, including sources of methane and nitrous oxide emissions from the soil, biological CO_2 emissions and soil carbon sinks, and fossil fuel combustion GHG emissions. For accounting purposes, the sources, sinks, and reservoirs included in the GHG Assessment Boundary are organized according to whether they are predominantly associated with an RC project's "primary effect" (i.e. the RC project's intended CH_4 reduction), or its "secondary effects" (i.e. unintended changes in carbon stocks, N_2O emissions, or other GHG emissions).[23] Secondary effects may include increases in mobile combustion CO_2 emissions associated with site preparation, as well as increased GHG emissions caused by the shifting of cultivation activities from the project area to other agricultural lands (often referred to as "leakage"). Projects are required to account for all SSRs that are included in the GHG Assessment Boundary regardless of whether the particular SSR is designated as a "primary" or "secondary" effect.

Table 4.1 provides a comprehensive list of the GHG sources, sinks, and reservoirs (SSRs) that may be affected by an RC project, and indicates which SSRs must be included in the GHG Assessment Boundary.

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

SSR	Source Description	Gas	Included (I) or Excluded (E)	Quantification Method	Justification/Explanation
Primary Effect Sources, Sinks, and Reservoirs					
1. Soil Dynamics	Soil dynamics refer to the biogeochemical interactions occurring in the soil that produce emissions of carbon dioxide (biogenic), methane , nitrous oxide, and changes in soil carbon stocks. GHG flux rates from soils are dependent on water management (including during seeding and after harvest), residue management, fertilizer application, and other site-specific variables	CO_2	I	DNDC	Changes in soil carbon stocks resulting from project activity may be significant. Decreases in carbon stocks must be accounted for.
		CH_4	I	DNDC	The primary effect of an RC project is reduction in methane emissions from soil due to reduced flooding and/or reduced organic residues available for decomposition.
		N_2O	I	DNDC	A Significant source affected by project activities if fertilizer application amounts and/or dates are changed, or seeding practice is altered.
Secondary Effect Sources, Sinks, and Reservoirs					

[22] The definition and assessment of sources, sinks, and reservoirs (SSRs) is consistent with ISO 14064-2 guidance.
[23] The terms "Primary Effect" and "Secondary Effect" come from WRI/WBCSD, 2005. *The Greenhouse Gas Protocol for Project Accounting*, World Resources Institute, Washington, DC. Available at http://www.ghgprotocol.org.

SSR	Source Description	Gas	Included (I) or Excluded (E)	Quantification Method	Justification/Explanation
2. Water Pumps	Indirect fossil fuel emissions from transport of water onto fields	CO_2	E	N/A	Excluded, as project activity is very likely to reduce or not impact the quantity of water used during the cultivation process as compared to baseline management.
		CH_4	E	N/A	Excluded, as this emission source is assumed to be very small.
		N_2O	E	N/A	Excluded, as this emission source is assumed to be very small.
3. Cultivation Equipment	Fossil fuel emissions from equipment used for field preparation, seeding, fertilizer/pesticide/herbicide application, and harvest	CO_2	I	Emission Factors	Emission may be significant if management is altered. Increased emissions due to project activity must be accounted for.
		CH_4	E	N/A	Excluded, as this emission source is assumed to be very small.
		N_2O	E	N/A	Excluded, as this emission source is assumed to be very small.
4. Crop Residue Baling	Fossil fuel emissions from baling and transportation of baled rice straw for offsite use/management	CO_2	I	Included in Baling Emission Factors	Emission may be significant if residue management is altered. Increased emissions due to project activity must be accounted for.
		CH_4	E	N/A	Excluded, as this emission source is assumed to be very small.
		N_2O	E	N/A	Excluded, as this emission source is assumed to be very small.
5. Crop Residue Management	Fugitive emissions from aerobic or semi-anaerobic rice straw management (on or off-site)	CO_2	E	N/A	Biogenic emissions are excluded.
		CH_4	I	Emission Factors	May be a significant source of fugitive methane emissions, depending on management/use of rice straw.
		N_2O	E	N/A	Due to low N content of rice straw, changes in N_2O emissions from alternative rice straw management are likely insignificant.
6. GHG Emissions from Shifted Production (Leakage)	If project activity results in a statistically significant decrease in yield, rice production and associated GHG emissions may be shifted outside the project area	CO_2	I		If rice yield totaled over all fields in an aggregate are found to have statistically decreased due to project activity, the associated GHG emissions from shifted rice production must be estimated.
		CH_4	I		
		N_2O	I		

5 Quantifying GHG Emission Reductions

GHG emission reductions from an RC project are quantified by comparing actual project emissions to baseline emissions from rice cultivation. Baseline emissions are an estimate of the GHG emissions from sources within the GHG Assessment Boundary (see Section 4) that would have occurred in the absence of the RC project. Project emissions are actual GHG emissions that occur at sources within the GHG Assessment Boundary. Project emissions must be subtracted from the baseline emissions to quantify the project's total net GHG emission reductions. GHG emission reductions are calculated for each individual field and summed together for an aggregate total.

Project emission reductions must be quantified and verified on an annual basis. The length of time over which GHG emission reductions are quantified and verified is called the "reporting period." The project's reporting period must include the complete cultivation cycle on all participant rice fields. Because different fields may have cultivation cycles that start on different dates, and the length of the cultivation cycle may be slightly more or less than a full 365 days on individual fields, the reporting period must be uniformly defined for the aggregate. Thus, for reporting purposes, the aggregate reporting period shall be defined as starting on October 1, and ending on September 31 of the next year.

The primary effect of an RC project is a reduction in methane emissions due to either i) a decrease in duration of flooded conditions (switching to dry seeding with delayed flood), or ii) a decrease in the availability of degradable organic matter in the soil (residue baling). While there is directional certainty (i.e. it is likely that project cultivation changes will reduce methane emissions compared to the baseline scenario), the magnitude of reductions is highly variable and dependent on numerous other parameters related to field-scale management techniques, soil characteristics, and climatic conditions. In order to accurately quantify the baseline and project methane emissions, and ensure that changes in related but secondary emissions of nitrous oxide and changes in soil carbon stocks are properly accounted for, this protocol relies on the application of the DNDC model for quantification of baseline and project emissions from Soil Dynamics (SSR-1) defined in Section 4. Detailed requirements for accurate and consistent application of the DNDC model are provided in Section 5.1 below.

In addition to SSR-1, RC projects may result in unintended project increases to GHG emission from other secondary SSRs. Section 5.2 provides requirements for calculating those secondary GHG emissions resulting from the project activity.

Total emission reductions from a field are equal to the combined modeled primary emission reductions from SSR-1 for all fields in the project boundary, minus the increase in emissions from all other SSRs due to the project activity. Equation 5.1 below provides the emission reduction calculation.

Equation 5.1. Calculating GHG Emission Reductions

$$ER = SDER - SE$$

Where, Units

ER	=	The total emission reductions from the project area for the reporting period	$MTCO_2e$
SDER	=	The total modeled GHG emission reductions from soil dynamics (SSR-1) from the entire project aggregate during the reporting period, as calculated in Section 5.1)	$MTCO_2e$
SE	=	The total Secondary Effect GHG emissions caused by project activity during the reporting period for the entire project aggregate (as calculated in Section 5.2)	$MTCO_2e$

5.1 Modeling Primary Effect Emission Reductions with the DNDC Model

For the purposes of this protocol, the modeling of GHG emissions from soil dynamics under baseline and project scenarios must be performed using an approved version of the DNDC model.[24] A separate and complete model run must be performed for each individual rice field in an aggregate.

Under this methodology, aggregation of multiple rice fields is encouraged because structural model uncertainty, which is quantified by comparing modeled gas fluxes to actual measured gas fluxes across multiple modeling runs, decreases with increasing number of independent model runs performed. The uncertainty adjustment factors (presented in Section 5.1.7 and derived in Appendix C) that must be applied to the modeled emission reduction results are inversely proportional to the number of fields (and thus the number of independent model runs) included in the aggregate.

Section 5.1.1 through Section 5.1.8 provides the quantification approach for determining the total primary modeled emission reductions for each rice field.

5.1.1 Parameterizing the DNDC Model

The DNDC model must be properly parameterized with appropriate field-level data related to soil characteristics, climatic drivers, water and residue management, and other related parameters. For each field, a separate model run is performed using a separate input parameter file (“*.dnd”) for the ‘baseline’ scenario and the ‘project’ scenario. The difference between the two emissions estimates (after accounting for input uncertainty) is the total emission reductions achieved from the project activity at the field. The modeling runs are performed for an entire ‘cultivation cycle’ to get net reductions for the field over the reporting period.

Model inputs are classified into two categories: project inputs and static inputs. The ‘project inputs’ are those that relate to the management parameters that are being changed as a result of the project activity (i.e. seeding practices and/or residue management practices). The project inputs to the DNDC model are the only parameters that will vary when modeling baseline and.

[24] All approved versions of the DNDC model will be available on the Reserve’s website.

project emissions to determine the GHG reductions related to the field's management change. All other inputs that are used to parameterize the model are referred to hereafter as 'static inputs' because once determined for a field for a given cultivation cycle, these inputs must remain unchanged when modeling baseline vs. project emission scenarios over the cultivation cycle.

Refer to Table 6.1 in Section 6 for a list and description of all DNDC input parameters.

5.1.1.1 Determining the Baseline Scenario Inputs

To define a baseline scenario for a field, it is necessary to assign values to each of the inputs related to the baseline water, residue, seeding, and fertilizer management. These project inputs make up what is referred to as the 'baseline scenario' for each field. Once the baseline project inputs are set, they must remain unchanged for the entirety of the crediting period (representing the baseline management scenario). The baseline scenario must represent the historical field management practices related to seeding practices, residue management practices, and winter flooding practices.

The following project inputs must be set individually for each rice field included in the project area using field-level management records going back a full 5 years (5 cultivation cycles) prior to the project start date.

Table 5.1. Determining Baseline Project Inputs

Baseline Practice	Project Input
Seeding	Dates of flooding relative to the planting date
	Dates of all fertilization events relative to planting date (both pre-flood and top-dressed after flooding)
Residue Management	Proportion of straw removed after harvest (0 if no straw removed)
	Quantity of additional fertilizer used to account for nutrient losses following straw removal
Fertilizer	Dates of all fertilizer applications
	Rate, type of fertilizer and application method for each fertilizer application
Tillage	Dates and depth of all tillage events for preparing the fields for planting and post-harvest residue management

5.1.1.2 Static Input Parameters

Static inputs are those that, while absolutely necessary for complete modeling, are not directly related to project activities. All static inputs should be based on actual field-level data for each cultivation cycle (unless otherwise specified), and must be the same when modeling baseline vs. project emissions for a specific cultivation cycle.

Climate Parameters

Seasonal weather can significantly affect methane emissions and, hence, the reduction in methane emissions due to project activities. Weather during the cultivation cycle will impact decisions made regarding the planting and harvesting dates, and therefore impacts the length of the growing season. The following requirements for determining climate parameter inputs for each cultivation cycle calculation must be met:

- Daily climate data must come from a weather station that is located maximally 20 miles away. If the project area is located in California, it is recommended to use weather data from the nearest CIMIS weather station (http://wwwcimis.water.ca.gov).
- Weather data for the five years preceding the start of the crediting period must be collected. Weather data for the twenty year historic period modeling run (see Section 5.1.2) must be set by repeating this five-year weather data set four times . After the start of the crediting period, actual weather data must be used for all emission calculations.
- Daily values of maximum temperature, minimum temperature, rainfall, and wind speed must be collected and formatted according to DNDC's climate file mode 1 format (Table below).

Table 5.2. Climate Parameters

Input Parameters	Unit
Jday (Julian day)	Day of year
MaxT (maximum temperature)	°C
MinT (minimum temperature)	°C
Rainfall	mm day^{-1}
Wind speed (daily average)	meters $second^{-1}$ day^{-1}

Static Management Parameters

All static management parameters must be set for each cultivation cycle based on actual data as they are assumed to have been identical regardless of the existence of the project activity. As with all other static inputs, the values for the following management parameters must be identical in the baseline and project model run for each cultivation cycle during the crediting period. All of the following variables must be collected for each cultivation cycle during the crediting period:

Table 5.3. Static Management Parameters

Input Parameters	Unit
Date of pre-planting field preparation	Date
Planting date	Date
Fertilization amounts and dates, and type of fertilizer used after seeding prior to harvest	Lbs per acre, date, type (e.g. nitrate, ammonium, or urea)
Rice Straw Fraction Burned	Fraction of total (by area or weight)
Harvesting date	Date
Winter Flooding Practices	Dates of winter flooding events (single or maintenance) relative to harvest dates

Soil Data

Some soil parameters affect methane emissions to a significant extent. Therefore, for each of the individual rice fields, values for the following inputs must be obtained either from the USDA NRCS SSURGO data set, or based on soil measurements:

- Clay Content
- Bulk Density
- Soil pH
- Soil Organic Carbon (SOC) at Surface Soil (top 5 cm)
- Soil Texture

If using soil measurements, data may not be older than 10 years prior to field's project start date. Official soil laboratory statements must be available during the verification process. See Section 6 for more guidance on determining soil inputs.

5.1.2 Historical Modeling Run and Crop Yield Calibration

The DNDC model must be run for at least 20 years before the start of the crediting period so that the model can attain equilibrium in certain critical variables for which empirical data are lacking, such as the sizes and the quality of the different carbon pools, and the inorganic nitrogen contents of soil pore water. This period is referred to as the historical period. The input parameters for the 20-year historical period must be set by repeating all parameters from the five years before the start of the crediting period four times, unless otherwise noted.

The last five years of the historical period must be used to calibrate the modeled crop yields (see discussion below). Table 5.2 provides the schematic for the modeling period for each field.

Table 5.4. Schematic of Modeling Period

Year -20 to -15	Year -15 to -10	Year -10 to -5	Year -5 to 0	Year 0 to 5	Year 5 to 10
Historical Period				*Crediting Period*	
Model Equilibration			Crop Yield Calibration	Crediting Period 1	Crediting Period 2

Source: Figure adapted from Proposed VCS Methodology: Calculating Emission Reductions in Rice Management Systems.

Crop Model Calibration

Proper parameterization of soil physical conditions (which drive soil moisture dynamics) and crop simulation play a crucial role in modeling C and N biogeochemistry and N_2O emissions. Through transpiration and N uptake as well as depositing litter into soil, plant growth regulates soil water, C and N regimes, which in turn determine a series of biogeochemical reactions impacting soil carbon dynamics, CH_4 and N_2O emissions. Users shall calibrate the DNDC crop model for cropping systems to be included in the project. Figure 1 outlines the steps for crop calibration. In DNDC, crops are defined by the following parameters:

- ***Maximum biomass (kg C/ha)***: The maximum biomass productions for grain, leaves+stems (non-harvest above ground biomass), and roots under optimum growing conditions (namely, maximum biomass assuming no N, water or growing degree day limitations). The unit is kg C/ha (1 kg dry matter contains 0.4 kg C). Maximum yield values will be used for step 2 in figure 1 below.
- ***Biomass fraction***: The grain, leaves+stem, and root fractions of total biomass at maturity.
- ***Biomass C/N ratio***: Ratio of C/N for grain, leaves+stems, and roots at maturity.
- ***Thermal degree days (°C)***: Cumulative air temperature from seeding till maturity of the crop.
- ***Water demand (g water/g dry matter***): Amount of water needed for the crop to produce a unit of dry matter of biomass.
- ***N fixation index***: The default number is 1 for non-legume crops. For legume crops, the N fixation index is equal to the ratio (total N content in the plant)/(plant N taken from soil).

Default values for these parameters for rice are provided with DNDC and can be found in the C:\DNDC\Library\Lib_crop directory. This parameterization is sufficient in most circumstances as long as the "maximum biomass" parameter is manually set in the model based on historical yields. More specifically, the "maximum biomass" parameter of the DNDC model must be manually tuned so that DNDC predicts the recorded yields during the five years before the start of the project as well as possible with a maximal relative RMSE of 10% of the observed means.

However, project aggregators must demonstrate that DNDC has been properly calibrated to each field using actual site conditions. At least 5 years of observed crop yields should be used for maximum grain yield (kg C/ha), biomass fraction (% grain and % leaf and stem), and biomass C:N ratio for grain, leaves and stem, and roots. The steps for crop calibration are outlined below and shown in Figure 5.1.

To carry out the crop calibration process, the user must use the following steps for the single year out of the last five that had the maximum observed rice yield:

1. **Adjust maximum biomass parameter**:
    a. Enter observed maximum biomass and fraction for grain, leaf and stem and root[25];
    b. Provide more than adequate fertilization (*i.e.* use the auto-fertilization option in DNDC);
    c. Provide more than adequate irrigation (*i.e.* use the irrigation index mode and set the index to 1);
    d. Run the year (or rotation) with the actual local climate/soil conditions;
    e. Check the modeled grain yield – the difference between the modeled and observed grain yield should be less than 10%:
        i. If the difference is greater than 10% and the modeled grain yield is less than the actual yield, increase the maximum biomass parameter;
        ii. If the difference is greater than 10% and the modeled grain yield is greater than the actual yield, decrease the maximum biomass parameter.
2. **Adjust accumulative thermal degree days (TDD)**: Check the modeled maturity date – this can be found in the "Day_FieldCrop.csv" file[26]: the last column of this file, "GrainC", shows daily grain weight (kgC/ha); the maturity date can be inferred by checking the last day where there is an increase in grain weight (*i.e.* the first day where the grain weight levels off):
    a. If the modeled maturity date is later than the harvest date, you will need to reduce the TDD value;
    b. If the modeled maturity date is earlier than the harvest date, you will need to increase the TDD value.
3. **Adjust water requirement**: Change irrigation practices back to actual management practices while maintaining the high fertilizer application rate and run the model again:
    a. If the modeled yield/biomass is lower than observed yield/biomass, decrease the water requirement value;
    b. If the modeled yield/biomass is higher than observed yield/biomass, increase the water requirement value.

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[25] Biomass fraction and C:N ratios are typically constant for a cultivar, so if this data are not available for the farm to be modeled, the information can usually be acquired from the local university extension.

[26] This file will only be available in the site results if the "record daily results" option is selected on the climate tab of the DNDC GUI.

A flow-chart, Figure 5.1, illustrates this calibration process.

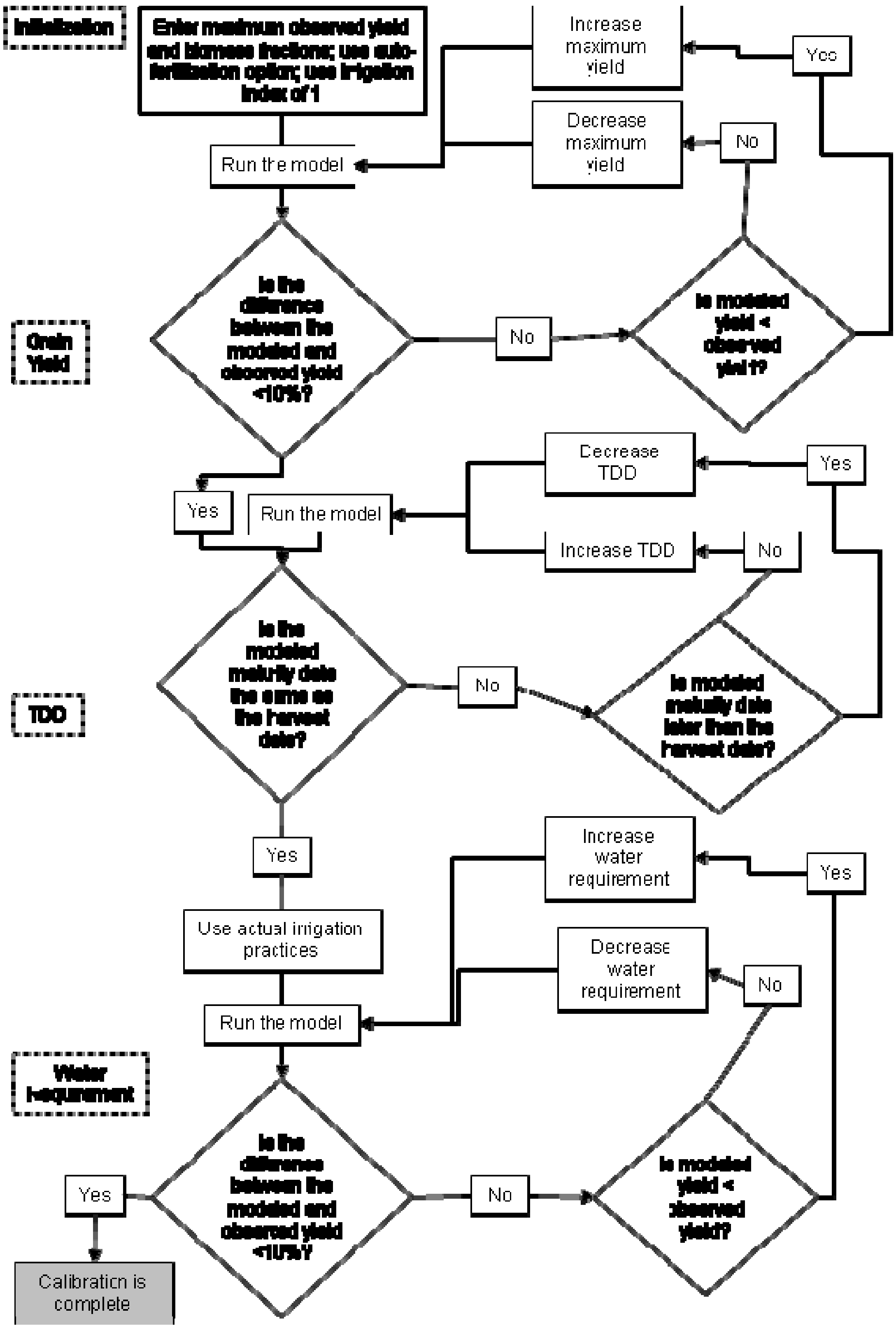

Figure 5.1. Flowchart for Calibrating DNDC Model

5.1.3 Monte Carlo Simulations to Account for Soil Input Uncertainty

Soil physical and chemical properties have a significant impact on CH_4 and N_2O production, consumption and emissions. Project aggregators have the choice of estimating soil conditions based on field samples or soil surveys. If field measurements are used, then the target precision level for each soil parameter shall be +/-10% of the mean at a 90% confidence level. The distribution of the field values shall be assumed to be normally distributed.

If NRCS SSURGO soil survey data[27] are used for setting soil parameters, then default uncertainty estimates shall be set based on uncertainty estimates and probability distribution functions (PDF) listed in Table 5.5. For each stratum, the mean value shall be calculated as the area-weighted sum of the representative values for all compartments with the SSURGO MUKEY.[28]

Table 5.5. Uncertainty Estimates and Probability Distribution Functions for Soil Parameters[29]

Parameter	PDF	Uncertainty
Bulk density	Log-normal	0.1 g/cm^3
Clay content	Log-normal	+/- 10%
SOC	Log-normal	+/- 20%
pH	Normal	+/- 1 pH unit

A selection of 2,000 soil parameter (SOC, pH, clay fraction and bulk density) combinations shall be compiled for the Monte Carlo DNDC model runs (see Sections 5.1.4 and 5.1.5 below). The soil parameter combination will be a random selection for each parameter based on the PDF and uncertainty estimates (derived from field measurements). From the Monte Carlo runs, the uncertainty deduction for input uncertainty is calculated as the half-width of the 90% confidence interval.

5.1.4 Modeling Field Level Baseline Emissions

The baseline ($GHG_{BSL\ i,j}$) GHG emissions for each field *i* will be determined by performing a Monte Carlo simulation with 2,000 DNDC simulations using project input parameters determined in the baseline scenario, and static inputs based on actual data for the cultivation cycle.

Because of the uncertainty of input soil parameters (Table 5.5), DNDC must be run through a Monte Carlo analysis for baseline emission calculations. The duration of each Monte Carlo run should be the same as the duration of the cultivation cycle for the field. The Monte Carlo runs will be accomplished by running DNDC in batch mode with each entry in the batch file list representing a separate Monte Carlo run (see DNDC user's guide about running in batch mode).

Once the Monte Carlo runs are complete, results are recorded in a CSV file. The name of the file is the site name as entered into DNDC. From the CSV file extract the N_2O and CH_4 emissions and change in SOC content for each Monte Carlo run *j* in each field *i*.

[27] See http://soils.usda.gov/survey/geography/ssurgo/.
[28] Polygon GIS layers are linked to attribute tables via an attribute called MUKEY.
[29] Source Selected from http://www.abdn.ac.uk/modelling/cost627/Questionnaire.htm

Table 5.6. Extracted Baseline Emissions and Changes in SOC

			Units
$N_2O_{BSLj,i}$	=	Annual baseline N_2O emissions from rice field *i* from Monte Carlo run *j*	kg N_2O-N.ha^{-1}
$CH_{4,\ BSLj,i}$	=	Annual baseline CH_4 emissions from rice field *i* from Monte Carlo run *j*	kg CH_4-C. ha^{-1}
$SOC_{BSLj,i}$	=	Annual baseline change in soil organic carbon content from rice field *i* from Monte Carlo run *j*	kg dSOC-C

Calculate total average greenhouse gas emissions in metric tons (t) CO_2-e.ha^{-1} for field *i* for all Monte Carlo runs as follows:

$$GHG_{BSL,j,i} = N2O_{BSL,j,i} * \frac{44}{28} * GWP_{N2O} + CH4_{BSL,j,i} * \frac{16}{12} * GWP_{CH4} + SOC_{BSL,j,i} * \frac{44}{12} \quad (1)$$

$$GHG_{BSL\_i} = \frac{\sum_{j=1}^{n} \left(GHG_{BSL,j,i} \right)}{n} \quad (2)$$

Where,

			Units
$GHG_{BSL\_,i}$	=	Greenhouse gas emissions for field *i* as a result of management activities within the project boundary in the baseline	t CO_2-e.ha^{-1}
j	=	*1, 2, 3 … n* Monte Carlo runs	

5.1.5 Modeling Field Level Project Emissions

The project ($GHG_{P,i,j}$) GHG emissions in each field *i* for each Monte Carlo run *j* will be determined by running DNDC based on actual project input data. For the field being modeled, the project inputs should be adjusted to represent the project activities that occurred on the field during the cultivation cycle, and the static inputs must not change from the baseline model for the cultivation cycle. Based on the uncertainty of input soil parameters quantified in Section 5.1.3, DNDC will again be run through a Monte Carlo analysis for project emission calculations. The duration of each Monte Carlo run should be the same as the duration of the cultivation cycle for the field. The Monte Carlo runs will be accomplished by running DNDC in batch mode with each entry in the batch file list representing a separate Monte Carlo run (see DNDC user's guide about running in batch mode).

Once the Monte Carlo runs are complete, results are recorded in a CSV file. The name of the file is the site name as entered into DNDC. From the CSV file, extract the N_2O and CH_4 emissions and change in SOC content for Monte Carlo run *j* in field *i*.

Table 5.7. Extracted Project Emissions and changes in SOC content

			Units
$N_2O_{Pj,i}$	=	Annual project N_2O emissions from rice field *i* from Monte Carlo run *j*	kg N_2O-N.ha^{-1}
$CH_{4,P,j,i}$	=	Annual project CH_4 emissions from rice field *i* from Monte Carlo run *j*	kg CH_4-C. ha^{-1}
$SOC_{P,j,i}$	=	Annual project change in soil organic carbon content from rice field *i* from Monte Carlo run *j*	kg NH_3-N.ha^{-1} + NO_X-N.ha^{-1} volatilized

Calculate total average greenhouse gas emissions in metric tons (t) CO_2-e.ha^{-1} for field *i* for all Monte Carlo runs as follows:

$$GHG_{P,j,i} = N2O_{P,j,i} * \frac{44}{28} * GWP_{N2O} + CH4_{P,j,i} * \frac{16}{12} * GWP_{CH4} + SOC_{P,j,i} * \frac{44}{12} \quad \textbf{(3)}$$

$$GHG_{P\_i} = \frac{\sum_{j=1}^{N} \left(GHG_{P,j,i} \right)}{n} \quad \textbf{(4)}$$

Where, Units

GHG_{P_i}	=	Greenhouse gas emissions for field *i* as a result of management activities within the project boundary in the project	t CO_2-e.ha^{-1}
j	=	*1, 2, 3 … N* Monte Carlo runs	

5.1.6 Adjusting Field Model Results for Soil Input Uncertainty

The Monte Carlo analysis performed for the baseline and project GHG modeling must be used to calculate an input uncertainty deduction for each field in order to adjust for model uncertainty due to soil input uncertainties. The input uncertainty ($\mu_{inputs,i}$) for greenhouse gas emissions due to uncertainty in soil input parameters for field *i* shall be calculated as the half-width of the 90% confidence interval of the modeled reductions, where the modeled reductions for each Monte Carlo run *j* are calculated as:

$\mu_{inputs,i}$ = half-width of 90% CI of distribution of $(GHG_{BSL\_i,j} - GHG_{P\_i,j})$ expressed as a percent of the mean GHG emission reduction of field *i.*

The deductions for input uncertainty are applied effectively at the field level as shown in Equation 5.2 below.

5.1.7 Calculation of GHG Emission Reductions for the Aggregate

The total primary effect greenhouse gas emission reductions (tCO_2eq) for an entire project aggregate are calculated as:

Equation 5.2. Total Primary Effect GHG Emission Reductions for Aggregate

$$MPER = \mu_{struct} * \sum_{i=1}^{m} \mu_{inputs\_i} * (GHG_{BSL,i} - GHG_{P,i})$$

Where,

SDER	=	Modeled primary effect GHG emissions reductions over the project area
m	=	Number of individual rice fields included in the project area
$\mu_{inputs,i}$	=	Accuracy deduction factor for individual rice field *i* due to input uncertainties (% reduction for each field)
GHG_{P_i}	=	Project emissions in year *y* for individual rice field *i*
GHG_{BSL_i}	=	Baseline emissions in year *y* for individual rice field *i*
μ_{struct}	=	Accuracy deduction from model structural uncertainty (% reduction), must use the appropriate value in Table 5.7

5.1.7.1 Structural Uncertainty Adjustments

Inherent in biogeochemical models, like DNDC, are uncertainties due to imperfect science in the models. This uncertainty is often referred to as model structural uncertainty. Model structural uncertainty is quantified by comparing model estimates of greenhouse gases with measured emission estimates. The measured data are assumed to have no uncertainty (although measurements can have sources of uncertainties in practice). This section provides the results of the structural uncertainty derivation developed to adjust DNDC results for model structural uncertainty. To ensure conservativeness in estimates of project emission reductions, all project aggregates must use the adjustments listed in Table 5.7 below to account for structural uncertainty in the DNDC model, as specified in Equation 5.2.

The approach used to determine DNDC model structural uncertainty is described in more detail in Appendix C. Table 5.7 below presents the uncertainty adjustments that must be used for aggregates in California. The model structural uncertainty deduction, μ_{struct}, must be selected from table 5.1 based on the number of fields in the aggregate.

Because there is on-going field research actively collecting GHG emissions data for California rice, new data may become available for model validation. Periodically, as data become available, the calculation of model structural uncertainty and table of structural uncertainty factors will be updated. The most up to date table will be provided on the Reserve website. RC project aggregates must use the most current uncertainty deduction table available on the Reserve website for determining μ_{struct} at the time of verification.

Table 5.7. Structural Uncertainty Deduction Factors for Projects within California

Number of fields (m)	u_{struct}
1	51%
2	62%
3	68%
4	71%
5	74%
6	76%
7	77%
8	79%
9	80%
10	81%
15	84%
25	87%
50	91%
100	93%
1000	98%

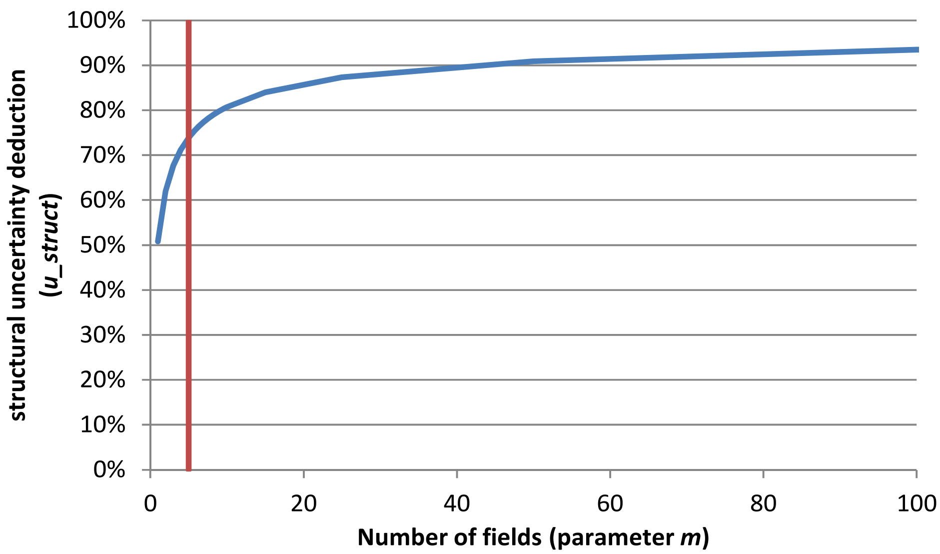

Figure 5.2. Model Structural Uncertainty

5.2 Quantifying Secondary Effects

Secondary effect GHG emissions are unintentional changes in GHG emissions from the secondary SSRs within the GHG Assessment Boundary. Secondary effect emissions may increase, decrease, or go unchanged as a result of the project activity. If emissions from secondary SSRs increase as a result of the project, these emissions must be subtracted from the total modeled primary emission reductions (as specified in Equation 5.1) for each reporting period on an *ex-post* basis.

As shown in Equation 5.3, the total secondary effect GHG emissions are equal to:

- Increased carbon dioxide emissions from mobile and stationary combustion of fossil fuels by farm equipment used for field preparation, seeding, cultivation (SSR 3), plus
- Carbon dioxide emissions from transport and processing of rice straw residues (SSR 4), and methane emissions from aerobic or semi-anaerobic treatment/use of baled rice straw residue (SSR 5), plus
- Emissions of methane and carbon dioxide due to shifted rice production outside the project boundary (SSR 6)

Equation 5.3. Total Secondary Effect Emissions from Project Activity for the Project Aggregate

$$SE = \sum_{fields} SE_{FF,f} + SE_{RM,f} + SE_{PS,f}$$

Where, Units

$SE_{FF,f}$	=	The total secondary effect GHG emissions from increased fossil fuel combustion for field 'f', as calculated in Section 5.2.1	$MTCO_2e$
$SE_{RM,f}$	=	The total secondary effect GHG emissions from alternative residue management for field 'f', as calculated in Section 5.2.2	$MTCO_2e$
$SE_{PS,f}$	=	The total secondary effect GHG emission from production shifting outside of the project boundary, as calculated in Section 5.2.3	$MTCO_2e$

5.2.1 Project Emissions from On-Site Fossil Fuel Combustion (SSR 3)

On-Site Stationary Combustion

Included in the GHG Assessment Boundary are secondary carbon dioxide emissions resulting from increased fossil fuel combustion for on-site equipment used for performing RC management activities related to seeding, fertilizer application, harvesting, rice straw management etc.

If the project management changes require new equipment or an increase in the operational hours for existing equipment, the CO_2 emissions from the increased fossil fuel combustion shall be calculated per Equation 5.4 below.

Equation 5.4. Project Carbon Dioxide Emissions from Fossil Fuel and Grid Electricity

$$PE_{CO_2} = \sum_{m} PE_{CO_2,FF} + PE_{CO_2,GE}$$

Where, Units

$PE_{CO2,FF}$	=	The total carbon dioxide emissions from the destruction of fossil fuel during the reporting period	$MTCO_2$
$PE_{CO2,GE}$	=	The total indirect carbon dioxide emissions from the consumption of electricity from the grid during the reporting period	$MTCO_2$

$$PE_{CO_2,FF} = \frac{\sum_{i} \left(FF_{PR,i} * EF_{FF,i}\right)}{1000}$$

Where, Units

$FF_{PR,I}$	=	Total increase in fossil fuel consumed by on-site combustion during the reporting period, by fuel type i	Volume Fossil Fuel
$EF_{FF,i}$	=	Fuel specific emission factor, reference from Appendix A	$kgCO_2$ / Volume Fossil Fuel
1000	=	Kilograms per tonne	$kgCO_2/tCO_2$

5.2.2 Project Emissions from Rice Straw Residue Management/Use

Project emissions from rice straw management consist of CH_4 produced from anaerobic or semi-anaerobic decay of the rice straw, and fossil fuel emissions that are used for swathing, raking, and baling of the rice straw. Depending on the end-use of the rice straw, the magnitude of the emissions will vary, but may be significant. If rice straw is unused and accumulates in piles on or near the farm, anaerobic decay will produce emissions that are quite significant, potentially outweighing the GHG benefits of baling the rice straw. Because the 'swathing, raking, and baling' services are most often performed by third party contractors, fossil fuel emissions from the 'swathing, raking, and baling' process are estimated using conservative default factors.

For calculating the emissions from rice straw management and/or use, emission factors were developed for the following identified end-uses:[30]

- **Dairy replacement heifer feed.** Wheat straw is traditionally used in heifer feed. Rice straw can be used if it is cut to the right length. Quality of the straw (crude protein content, moisture content, etc.) must meet minimal standards before it can be used. There may be a significant effect on enteric fermentation from replacing wheat straw by rice straw due to feeding animals lower quality straw.

- **Beef cattle feed.** Rice straw is used by beef cattle operations as a dry matter supplement to pasture feeding during fall and winter. Cattle ranchers spread the large bales out on the range in fall and allow the cattle to feed on the bales. Quality of the

[30] End-uses and descriptions referenced from ANR, 2010.

straw (crude protein content, moisture content) must meet minimal standards before it can be used. There may be some effects on enteric fermentation by feeding lower quality straw.

- **Animal bedding.** Application of straw to soil at dairies and feedlots as a way to help preserve and dry the soil is a well-established, longstanding use of rice straw. The decomposition of the straw will be assumed to be mostly aerobic.

- **Fiberboard Manufacturing.** Rice straw may be used as an alternative to wood products for the manufacturing of fiberboard. The avoided emissions from harvest and transport of wood products is likely net-positive.

- **Spread out on bare soils as erosion control.** Rice straw is particularly valuable for erosion control since it is produced in an aquatic environment and does not pose a risk of introducing upland weeds, unlike wheat or barley straw. When used for erosion control, rice straw will decompose aerobically.

- **Other uses.** Rice straw may be used in small quantities for other uses, such as being stuffed into netted rolls for soil loss prevention, or for use in mushroom farming (among other potential uses). Because of a lack of detailed emissions data, straw that is sent to an end-use other than those specified above must use the default emission factor for 'unknown or other' end-uses in Appendix A.

Each field must use Equation 5.5 to calculate the project CH_4 emissions from the end use of all baled rice straw. Because growers may not be able to track the end-fate for some or all of the fields rice straw, a conservative default factor can be used in place of and end-use specific default factor. If electing to use end-use specific factors, the grower must collect and retain straw sales documentation to demonstrate rice straw end-use(s). See Section 6.2.3 for detailed baling monitoring requirements.

Projects must use the emission factors in Table A.1 in Appendix A corresponding to the appropriate end use, or the default factor. If rice straw is unused and accumulates in piles on or near the field, the portion of rice straw that is left unused must be estimated, and the default factor for 'un-used' rice straw must be used to quantify the emissions from this source.

Equation 5.5. Emissions from Rice Straw End-Use

$$SE_{RM,f} = \left(W_{RS,f} \times EF_{SWB}\right) + \sum_{U} \left[W_{RS,U} \times EF_{U}\right]$$

Where, Units

$W_{RS,f}$	=	The total weight of rice straw in dry tons that is swathed, raked, and baled on the field	Dry MT
EF_{SWB}	=	The emission factor for increased fossil fuel emissions from swathing, raking, and baling. The emission factor shall be equal to 0.06 for all fields[31]	$MTCO_2e$ / Dry MT
$W_{RS,U}$	=	The weight of rice straw in dry tons with end use 'U'. The sum weight of rice straw to all end uses must equal the total weight of rice straw baled on the field	Dry ton
EF_u	=	The emission factor from Table A.1 in Appendix A for end use 'U'	$MTCO_2e$ / dry ton of straw

5.2.3 GHG Emissions from the Shift of Rice Production Outside of Project Boundaries

If rice yields decrease as a direct result of project activity, to be conservative it is assumed that the decrease in rice production causes a net increase in production elsewhere outside the project boundary. The emissions associated with this shift in production must be estimated if project related yield losses are statistically significant compared to historic and average yields. Although rice production in California and the U.S. is likely fairly inelastic in relation to price changes,[32] it is assumed for conservativeness that a statistically significant drop in rice yields due to project activities would result in an increase of production outside of the project boundary.

In order to determine if rice yields have decreased across the project area during the cultivation cycle as a result of project activity, the annual aggregate yield must be compared to historical yields from the same project area. Because yields fluctuate annually depending on numerous climatic drivers, all yields are normalized to average annual county yields using USDA NASS statistics.[33]

The following procedure must be followed for each cultivation cycle to ensure that the project aggregate yields have not declined due to project activity:

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[31] Emissions from swathing, raking, and baling the rice straw are likely to be similar to emissions from the avoided chopping and disking of the field. From University of California cost and return studies for rice (2007) and orchard grass hay (2006), conservative estimates of fuel usage were obtained for both scenarios. The emission factor assumes an increase in fuel usage equivalent to 2 Gallons of diesel fuel per acre for the swathing, raking, and baling. Using EPA diesel emissions factor of 8.78 kg CO_2 per Gallon of diesel, and assuming 3 MT of rice straw per acre, the emissions increase from swathing, raking, and baling is estimated to be 5.85 kg CO_2 /MT of rice straw. .

[32] McDonald et al. (2002), Russo et al. (2008).

[33] Available at (http://quickstats.nass.usda.gov)

1. For the five years t prior to implementation of the project, normalize the yield of each field by the county average for that year, and the sum the results for all fields in the aggregate to determine (**$y_{norm,t.}$**) for each of the five historic years. This distribution will have five data points.

2. For the present cultivation cycle, normalize the yield of each field by the county average for the growing season for the year, and sum the result for all fields in the aggregate to get (**$y_{norm,t0}$**). This represents one data point.

3. Take the standard deviation and mean of the **$y_{norm,t}$** distribution:

$$s = stdev(y\_norm_t)$$

$$\overline{y\_norm_t} = average(y\_norm_t)$$

4. Calculate the minimum yield threshold below which normalized yields are significantly smaller than the historical average. This shall be done as follows:

$$y\_min = \overline{y\_norm_t} \quad - t(0.05, n-1) \cdot s$$

Where n is 5, and $t(0.05, n-1)$ the t-distribution value with 95% confidence (for a one-tailed test) and $n-1$ degrees of freedom.

5. For every year of the crediting period, calculate **$y_{norm,t0}$** and compare this value to y_min. If $y\_norm_{t_0}$ is smaller than y_min, it must be assumed that emissions increased outside of the project area. The aggregate must account for increased emissions as specified in Equation 5.6 below.

Equation 5.6. Increased Emissions Outside the Project Boundary

$$SE_{PS,f} = \left(1 - \frac{y_{norm,t0}}{y_{\min}}\right) \times \sum_i GHG_{BSL,i}$$

Where, Units

$y_{norm,t0}$	=	The sum of yields for the current cultivation cycle normalized to the county averages.	Fraction
Y_{min}	=	The minimum yield threshold below which normalized yields are significantly smaller than the historical average.	Fraction

6 Project Monitoring

The Reserve requires a Monitoring Plan to be established for all monitoring and reporting activities associated with the project. Under this protocol, two distinct types of Monitoring Plans must be developed: an Aggregate-level Monitoring Plan and a Field-level Monitoring Plan.

The Aggregate-level Monitoring Plan (AMP) will serve as the basis for verifiers to confirm that the project aggregate tracking requirements in this section and Section 7 have been and will continue to be met for each cultivation cycle. The AMP must specify how the GIS shape-file and/or KML file will be created for each field, and how the crediting period, verification schedule, and quantification results will be tracked for each field included in the project aggregate. In addition, the AMP must include provisions for ensuring that the Title to the GHG emission reductions has been conferred to the aggregator as required in Section 2.3 for each field in the aggregate. Finally, the AMP must include procedures that the aggregator will follow to ascertain and demonstrate that all fields in the project aggregate at all times pass the Legal Requirement Test and the Regulatory Compliance Test (Section 3.6.2 and 3.7 respectively).

The AMP shall include a detailed record keeping plan (see Section 7.2 for minimum record keeping requirements); and specify the role of individuals performing each specific activity. The AMP must be developed and maintained by the aggregator.

The Field-Level Monitoring Plan (FMP) will serve as the basis for verifiers to confirm that the monitoring and reporting requirements in this section and Section 7 are met at each field in the project aggregate, and that consistent, rigorous monitoring and record-keeping is ongoing at each field. The FMP must cover all aspects of monitoring and reporting contained in this protocol and must specify how data for all relevant parameters in Table 6.1 (below) are collected and recorded at each field. One FMP must be developed for each project participant. If a project participant has multiple fields enrolled in the aggregate, only one FMP is required as long as it addresses the monitoring requirements at each field. The FMP can be developed by the project participant or the aggregator, depending on the arrangement specified in contractual agreements. It is the responsibility of the aggregator to ensure that the FMP meets all requirements specified, and is kept on file and up to date for verification.

At a minimum the FMP shall stipulate the frequency of data acquisition; a record keeping plan (see Section 7.2 for minimum record keeping requirements); the frequency of sampling activities; and the role of individuals performing each specific monitoring and sampling activity. The FMP should include QA/QC provisions to ensure that data acquisition is carried out consistently and with precision.

6.1 Aggregate-Level Monitoring Requirements

The aggregator must track the following information from each field enrolled in the aggregate and include it in an annual Aggregation Monitoring Report that will be retained for verification purposes and submitted to the Reserve following verification. The annual Aggregation Monitoring Report must contain the following information for each field:

- Either a GIS shape-file or a KML file clearly defining the field perimeter

- The most north-westerly point of the field, reported in degrees to four decimal places[34] (to be used for creating field serial numbers)
- The acreage of the field (acres)
- The Field Serial Number, to be determined by the following algorithm
  - First letter of the County, followed by degrees of the most north-western point of the field, (latitude, then longitude, both reported to 4 decimal places), followed by the acreage of the field. (Example: *B-39.6123-121.5332-76* would be a 76 acre field in Butte County, CA)
- Start date of the field
- Date field enrolled in the aggregate
- Current status of field (active, terminated, transferred to a different aggregate)
- Name of project participant associated with the field

6.2 Field-Level Monitoring Requirements

Each field in the project aggregate must monitor the necessary DNDC input data and field management data as specified below. In addition, each DNDC model input parameter must be determined according to the data source and frequency specified in Table 6.1 below.

6.2.1 Determining Field Soil Input Data

The modeling unit for DNDC in this protocol is an individual field, as defined in Section 2.2.1. Users of this protocol have the choice to either collect their own soil measurements, following the guidance in Section 6.2.1.1, or use the NRCS SSURGO soil survey. If the NRCS SSURGO soil database is used, then project developers must calculate the soil parameters for each project field on an area weighted basis. The figure below illustrates this concept for a rice field in Yolo County.

[34] Longitude reported in degrees to four decimal places provides a spatial resolution of ~11 meters, the resolution of the latitude is slightly less than that.

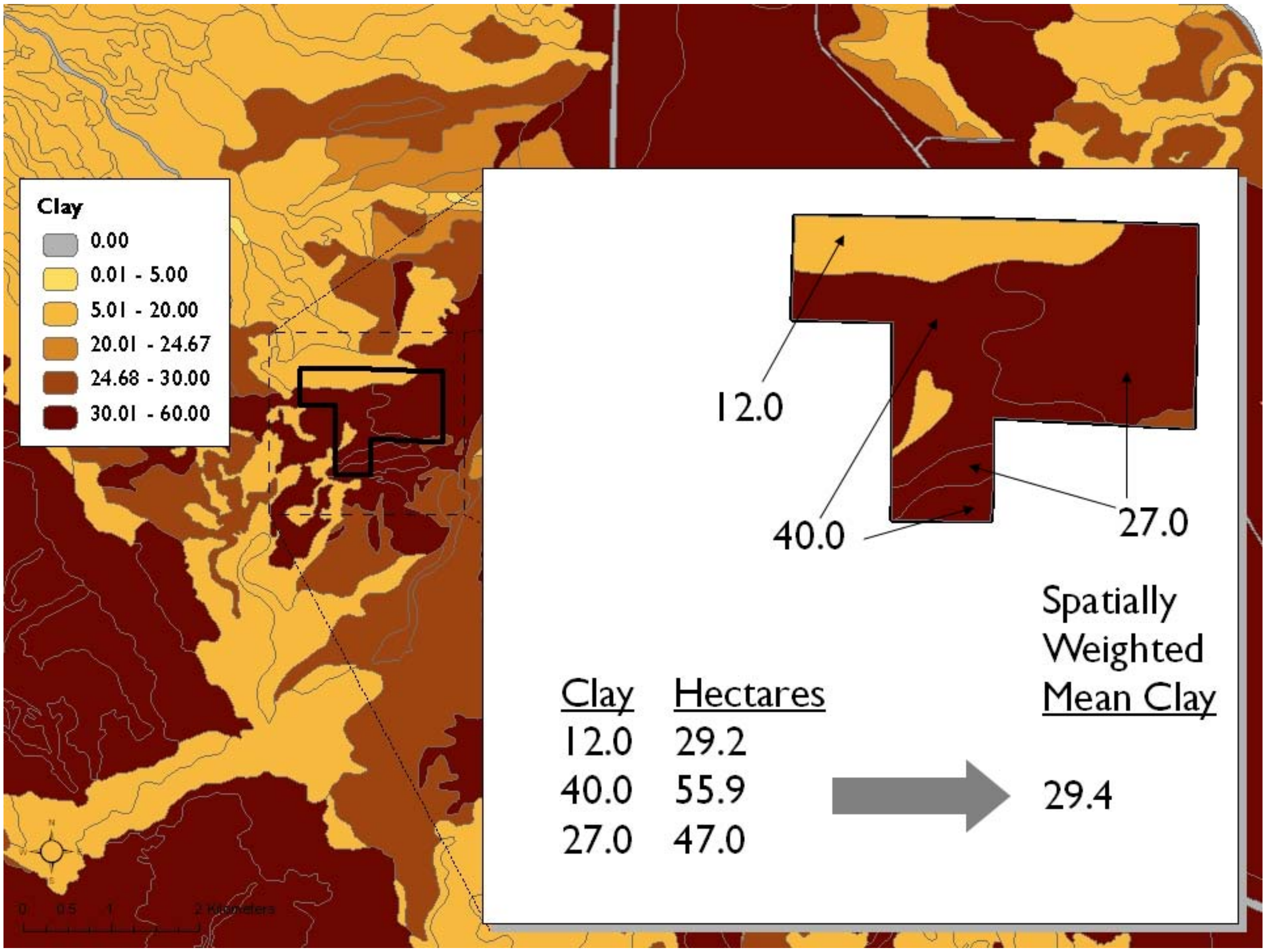

Figure 6.1. Example of Soil Parameter Area-Weighting using SSURGO Data

6.2.1.1 Soil Sampling Methodology

DNDC requires inputs of soil organic carbon content (top 5cm) and soil bulk density, pH and clay fraction of the top 10cm. If collecting samples for analysis, the following procedure must be used for each field:

- Samples should be collected at two depth increments: 0-5 cm and 0-10 cm
- Samples must be collected using a core method
- For each depth, 20 samples must be collected for the entire field
- To ensure spatial independence of soil properties, use a random sampling pattern
- Samples should be mixed together, by depth (i.e. samples from 0-5cm mixed together, and samples 5-10cm mixed together)
- The GPS coordinates and depth at each sampling location must be recorded
- The combined 0-5cm samples must be tested for all parameters
- The combined 0-10 cm samples must be tested for soil bulk density, pH, and clay fraction
- Soil samples must be analyzed by a certified soil laboratory

For each field sampling event, a Soil Sampling Log must be developed, including the following information:

- Date of Sampling Event
- Description of the core method and compositing procedure
- The GPS coordinates of each sampling location
- The Core depth of each sample
- The Name/Address of the 3rd Party Soil Sampling Contractor (if applicable)
- The Name/Address of the Certified Soil Laboratory used for analysis

Box 6.1. Derivation of the Required Number of Samples

The standard goal of collecting field data on soil properties is to have a sufficient number of soil samples so the soil conditions can be estimated within 10% of the actual mean value with a 90% level of confidence. Most soil chemical and physical properties are not normally distributed, but log-normally distributed. The number of samples required to achieve a given confidence level (e.g. 90%) and acceptable error (10%) was calculated as follows for the necessary soil parameters:[35]

Using the following equation:

$$n=t^2C^2/E^2$$

where,

n = number of soil samples for a field
t = Student's t-statistic that is for a 90% confidence interval
C = Coefficient of variation (standard deviation divided by the mean)[36]
E = acceptable error, a value of 10% must be used

Given that Both physical and chemical soil parameters are expected to have similar ranges for the coefficient of variation (15-40%, 25-45% respectively), a number (n) was chosen such that the expected coefficient of variation fell within each range. The **n** value chosen equals **20**, with a t-statistic of 1.725 at the 90% confidence level. Solving for C gives a value of 0.26, which is within the range of the expected coefficients of variation.

6.2.2 Field Management Data

The following management data must be collected and retained at each field for each cultivation cycle during the reporting period:

- Planting preparation description and date
- Planting date and method
- Fertilization types, amounts, and application dates
- Flooding[37] and drainage[38] dates (during the growing season, and during post-harvest period)
- Begin and end date of harvesting on the field

[35] Boone et al. 1999
[36] According to the USDA GraceNet sampling protocol, chemical soil properties have a spatial coefficient of variation (%CV) of 25 to 45% and physical properties 15 to 40% depending upon the scale of sampling. Thus, the number os samples
[37] For each field, the flood date shall be equal to the date that the first 'check' began filling
[38] For each field, the drainage date shall be equal to the date that the last 'check' began draining

- Post-harvesting residue management (e.g. burning, incorporation or baling) description and dates
- If baled:
  - Quantity of rice straw removed
  - Height of the cutting bar
  - Quantity of rice straw left unused in piles at or near the field
  - End use of rice straw (if using an end-use specific emission factor)

6.2.3 Project Activity Documentation:

To corroborate field management assertions, each field must retain the following documentation:

Dry Seeding with Delayed Flood:

- Seeding equipment purchase or rental records, and/or seeding service contracts/agreements/receipts
- At least four time-stamped digital photographs per field 'check' taken from various vantage points no more than 15 days after seeding. The pictures must clearly show an establishing stand with no standing water present.
- At least four time-stamped digital photographs per field 'check' taken from various vantage points during flood-up. The pictures must, clearly show the established stand.

Rice Straw Baling:

- Baling equipment purchase or rental records, and/or baling service agreements/receipts
- At least four time-stamped digital photographs per field 'check' taken from various vantage points during the swathing, raking, and baling process. Pictures must clearly show the baled hay post-baling.
- Log of baling process, recorded at the time of baling, including:
  - Date(s) that each stage of the swathing, raking, and baling process commenced and ended
  - Number of acres baled
  - List of equipment used
  - Height of the cutting bar used
  - Name of third party baling service provider (if applicable)
- If using an end-use specific emission factor, all sales contracts or receipts must be retained for verification purposes.

6.2.4 Field Monitoring Parameters

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

Table 6.1. Rice Cultivation Project Monitoring Parameters

Parameter	Description	Data Unit	Calculated (c) Measured (m) Reference(r) Operating Records (o)	Measurement Frequency	Comment
General Project Parameters					
Regulations	Aggregator attestation of compliance with Legal Requirement Test and Regulatory Test relating to the rice cultivation project	Regulatory requirements	n/a	Each verification cycle	Information used to: 1) demonstrate ability to meet the Legal Requirement Test 2) demonstrate compliance with associated environmental rules, e.g. criteria pollutant, residue burning, etc.
DNDC Input Parameters					
Climate	GPS location of Field	° decimal to four places	m	once	
	Atmospheric background NH_3 concentration	μg N/m^3	r	n/a	
	Atmospheric background CO_2 concentration	ppm	r	n/a	
	Daily Precipitation	cm	m	daily	Source: Nearest CIMIS station
	Daily maximum Temperature	° C	m	daily	Source: Nearest CIMIS station
	Daily minimum temperature	° C	m	daily	Source: Nearest CIMIS station
	N concentration in rainfall	mg N/l or ppm	r	Each verification cycle	Source: NADP
Soils**	Land-use type	type	m	once	
	Clay content	0-1	m/r	once	Source: measured or SSURGO
	Bulk density	g/cm^3	m/r	once	Source: measured or SSURGO
	Soil pH	value	m/r	once	Source: measured or SSURGO
	SOC at surface soil	kg C/kg	m/r	once	Source: measured or SSURGO
	Soil texture	type	m/r	once	Source: measured or SSURGO
	Slope	%	m	once	

Parameter	Description	Data Unit	Calculated (c) Measured (m) Reference(r) Operating Records (o)	Measurement Frequency	Comment
	Depth of water retention layer	cm	m	once	Default: 30cm
	High groundwater table	cm	m	once	Default: 9.9 meters
	Field capacity	0-1	c	once	DNDC calculates based on soil texture
	Wilting point	0-1	c	once	DNDC calculates based on soil texture
Rice Cropping	Planting date	date	m	annual	Famer's records
	Harvest date	date	m	annual	Famer's records
	C/N ratio of the grain	ratio	m/r	Once per variety	Can use default dnd file values
	C/N ratio of the leaf + stem tissue	ratio	m/r	Once per variety	Can use default dnd file values
	C/N ratio of the root tissue	ratio	m/r	Once per variety	Can use default dnd file values
	Fraction of leaves & stem left in field after harvest	0-1	m	annual	Farmer's records
	Maximum yield	kg dry matter/ha	m	annual	Farmer's records
Rice Flooding	Date of flood up for growing season	date	o	annual	Farmer's records
	Date of drain for crop harvest	date	o	annual	Farmer's records
	Date of flood up for winter flooding (if applicable)	date	o	annual	Farmer's records
	Date of drain for winter flooding (if applicable)	date	o	annual	Farmer's records
Tillage System	Number of tillage events	number	o	annual	Farmer's records
	Date of tillage events	date	o	annual	Farmer's records
	Depth of tillage events	6 depths†	o	annual	Farmer's records
N Fertilizer	Number of fertilizer applications	number	o	annual	Farmer's records
	Date of each	date	o	annual	Farmer's records

Parameter	Description	Data Unit	Calculated (c) Measured (m) Reference(r) Operating Records (o)	Measurement Frequency	Comment
	fertilizer application				
	Application method	surface / injection	o	annual	Farmer's records
	Type of fertilizer	type*	o	annual	Farmer's records
	Fertilizer application rate	kg N/ha	o	annual	Farmer's records (field average if using variable rate applications)
	Time-release fertilizer	# days for full release	o	annual	Farmer's records
	Nitrification inhibitors		o	annual	Farmer's records
Organic Fertilizer	Number of organic applications per year	number	o	annual	Farmer's records
	Date of application	date	o	annual	Farmer's records
	Type of organic amendment	type	o	annual	Farmer's records
	Application rate	kg C/ha	o	annual	Farmer's records
	Amendment C/N ratio	ratio	o	annual	Farmer's records
Irrigation System	Number of irrigation events	number	o	annual	Farmer's records
	Date of irrigation events		o	annual	Farmer's records
	Irrigation type	3 types‡	o	annual	Farmer's records
	Irrigation application rate	mm	o	annual	Farmer's records

†0, 5, 10, 20, 30, 50 cm
*DNDC accepts seven types of fertilizers: Urea, Anhydrous Ammonia, Ammonium Nitrate, Nitrate, Ammonium Bicarbonate, Ammonium Sulfate and Ammonium Phosphate.
‡Flood, sprinkler or surface drip tape
**Soil parameters for DNDC are for the properties of the top layer of the soil profile. If not measured, then look up values from NRCS SSURGO database is required.

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.

7.1 Project Aggregate Submittal Documentation

For each project aggregate, aggregators must provide the following documentation to the Reserve in order to submit and register the RC project aggregate.

- Project Aggregate Submittal form (which includes the initial number of fields and the names of project participants for each individual enrolled field)
- Signed Aggregator's Attestation of Title form
- Signed Attestation of Regulatory Compliance form
- Signed Attestation of Voluntary Implementation form
- Verification Report
- Verification Statement

Aggregators must provide the following documentation each subsequent reporting period in order for the Reserve to issue CRTs for quantified GHG reductions.

- Verification Report
- Verification Statement
- Annual Aggregate Monitoring Report (see Section 7.5 below for specific requirements)
- Signed Attestation of Title form
- Signed Attestation of Regulatory Compliance form
- Signed Attestation of Voluntary Implementation form

With the exception of the Aggregate Monitoring Reports, at a minimum, the above project documentation will be available to the public via the Reserve's online registry. Further disclosure and other documentation may be made available on a voluntary basis through the Reserve. Project submittal forms can be found at http://www.climateactionreserve.org/how/projects/register/project-submittal-forms/.

7.2 Record Keeping

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

7.2.1 Record Keeping on the Aggregate-Level

System information the aggregator should retain on for the Aggregate-level includes:

- All contractual arrangements with each project participant and/or land owner
- All letters of notification sent to land owners
- All GIS or KML shape files for all fields in the aggregate
- All north-western latitude/longitude coordinates for each field (to four decimal places)
- All Serial numbers for each field (according to the guidance in Section 6.1)

- All data inputs for the calculation of the project emission reductions, including all required sampled data and all DNDC input files (*.dnd files)
- Copies of all air, water, and land use permits relevant to project activities; Notices of Violations (NOVs) relevant to project activities; and any administrative or legal consent orders relevant to project activities dating back at least 3 years prior to the project start date, and for each subsequent year of project operation
- Executed Aggregator Attestation of Title forms, Attestation of Regulatory Compliance forms, and Attestation of Voluntary Implementation forms
- Results of CO_2e annual reduction calculations
- Initial and annual verification records and results

7.2.2 Record Keeping on the Field-Level

At each field, the following records should be retained for verification purposes:

- On-site fossil fuel use records
- Fertilizer purchase records
- All time-stamped digital photographs of the seeding, flooding, and baling activities (as specified in Section 6.2.3).
- Rice baling logs (as specified in Section 6.2.3)
- All maintenance records relevant to the farm equipment and monitoring equipment
- Rice straw sales receipts or contracts (if applicable)

7.3 Annual Monitoring Reports

7.3.1 Requirements for Annual Aggregate Monitoring Reports

For each cultivation cycle, upon successful completion of required verification activities, the aggregator must submit to the Reserve an annual Aggregate Monitoring Report (AMR). The AMR must have the following information:

- List of all fields and the corresponding serial numbers for each field
- A flag specifying whether the field is a new addition to the aggregate in the particular year
- The field start date
- The calculation results for each field (uncorrected for structural uncertainty)
- A flag for which fields had site visit verifications, desk audits, or were un-audited
- The total verified emission reductions for the aggregate (corrected for model structural uncertainty and any deductions due to errors or misrepresentations at the verified fields)

7.3.2 Requirements for Annual Field Monitoring Reports

For each cultivation cycle, a Field Monitoring Report (FMR) must be prepared for each field in the aggregate by the aggregator or the project participant (depending on the arrangement of services as specified in the contract). Each FMR will be retained by the aggregator for verification purposes. During each reporting year's verification, the FMRs for a given aggregate will be randomly sampled in order for the verifier to perform the necessary desk-audits as specified in Section 8.2. Because the FMR forms the basis for the verification desk audit, the report must be comprehensive. The FMR must include the following information:

- A copy of the GIS shape file or KML file for the field
- The Serial number of the field, constructed as specified in Section 6.1
- The start date of the field
- Disclosure of any material and immaterial regulatory violations, with copies of all Notices of Violation (NOVs) included in the report

- A list of the project activities implemented on the field during the cultivation cycle
- A copy of the DNDC input (*.dnd) files used as the input to the DNDC model for the 'baseline' scenario and 'project' scenario
- A copy of the DNDC modeling result, adjusted for input uncertainty
- A copy of all Field Management Data as specified in Section 6.2.2
- A copy of all the Project Activity Documentation for both Dry Seeding and Baling (if applicable) as specified in Section 6.2.3
- Copy of soil laboratory statements and the Soil Sampling Log for any sampled soil parameters
- Field rice yield during the cultivation cycle and the 5 years prior to the field start date

7.4 Reporting Period and Verification Cycle

Aggregators must report GHG reductions resulting from project activities for all fields during each reporting period, which represents a complete cultivation cycle. As a complete cultivation cycle may be slightly greater or less than 365 days for each field depending on planting/harvest dates. The length of the reporting period must be uniformly defined for the aggregate. Thus, for reporting purposes, the aggregate reporting period shall always be defined as starting on October 1, and ending on September 31 of the next year. Each field must quantify their emission reductions for the entire cultivation cycle, and the aggregate reductions will be reported on the uniform reporting period. Reporting periods must be contiguous; there can be no time gaps in reporting during the crediting period of an aggregate once the initial reporting period has commenced.[39] No more than a one reporting period can be verified at once, except during an aggregates first verification, which may include historical emission reductions from prior years.

Because a single reporting period spans two calendar years (from fall of one year to late summer/fall of the next), the aggregator must assign each reporting period a single 'vintage' for reporting purposes. For reporting reductions to the Reserve, the calendar year in which the rice crop is harvested represents the vintage year for the reporting cycle. For instance, all GHG reductions from a cycle beginning in fall 2012 and ending with harvest in late summer 2013 shall be assigned as 2013 'vintage' when reporting reductions to the Reserve.

[39] An entire aggregate can willingly forfeit CRTs for an entire cultivation cycle in accordance with the Reserve's zero-crediting period policy , available at: http://www.climateactionreserve.org/wp-content/uploads/2011/02/2011-Deadline-Zero-Credit-Policy-Memo.pdf

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 RC projects.

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

- Climate Action Reserve Program Manual
- Climate Action Reserve Verification Program Manual
- Climate Action Reserve Rice Cultivation Project Protocol

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

Only ISO-accredited verification bodies with lead verifiers trained by the Reserve for this project type are eligible to verify RC project reports. Verification bodies approved under other project protocol types are not permitted to verify RC 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/.

In addition, all verification bodies must have an accredited Professional Agronomist, Crop Advisor, or similar agricultural specialist on the verification team in order to verify RC projects.

8.1 Preparing for Verification

The project aggregator is responsible for coordinating all aspects of the verification process, coordinating with verifiers, project participants, and the Reserve and submitting all necessary documentation to verifiers and the Reserve.

The aggregator is responsible for selecting a single verification body for the entire project aggregate for each reporting period. The same verifier may be used up to six consecutive years (the number of consecutive years allowed, according the Reserve's Verification Program Manual[40]). Verification bodies must pass a conflict-of-interest review against all project participants and the aggregator.

Each year, project participants must submit all Field Monitoring Reports to the aggregator according to the guidelines in Section 7. Aggregators shall also make all Field Monitoring Plans (FMPs) available to the verifier, as well as the Aggregate Monitoring Plan (AMP), and the Aggregate Monitoring Report (AMR). The above documentation should be made available to the verifier after the NOVA-COI process is complete.

Aggregators may assist project participants in preparing documents for verification and facilitate the verification process. The scope of these services is determined by the specific contract between project participants and the aggregator. However, the ultimate responsibility for monitoring reports and verification compliance is assigned to the aggregator.

[40] http://www.climateactionreserve.org/wp-content/uploads/2010/12/2010-Verification-Program-Manual-12-201.pdf

A field is considered verified if it is in the pool of fields for which site visits or desk audits are conducted, even if not selected for either a site visit or desk audit. As a preliminary step in preparing for verification, the aggregator may choose to exclude fields from the pool of fields that may be selected for verification activities. Aggregators must report to the verifier all instances of field exclusion. The excluded fields shall be removed from the acreage totals and field numbers used to determine field eligibility and verification sampling methodologies in Section 8.2and as such are not considered verified.

8.2 Verification Sampling and Schedule

Guidelines for verification sampling of the aggregate and the aggregate's verification schedule are different for "small aggregates," "large single-participant aggregates," and "large multi-participant aggregates". This approach allows a consistent application of verification requirements across all aggregates regardless of size or number of participants.

In all cases, the verification schedule shall be established by the verifier using random sampling, according to the verification schedule and sampling methodologies outlined in Sections 8.2.1, 8.2.2 and 8.2.3. These sampling methodologies establish the minimum verification frequencies; the verifier may at any time add fields beyond the minimum number required for site-visit and/or desk-audit verification and may use verifier 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 sampling requirements are mandatory regardless of the mix of entry dates represented by the group of fields in the project aggregate.

The initial site-visit verification schedule for a given year shall be established after the completion of the NOVA-COI process and prior to the commencement of any verification activities. This is meant to allow for the aggregator and verifier to work together to develop a cost-effective and efficient site visit schedule. Specifically, once the sample fields designated for a site visit has been determined, the verifier shall document all fields selected for planned site-visit verification and provide a list to the aggregator and the Reserve. The aggregator shall be responsible for informing project participants of their selection for a planned site-visit. Following this notification, the aggregator shall supply the verifier with all the required documentation to demonstrate field-level conformance to the protocol. When a verifier determines that additional sampling is necessary, due to suspected non-compliance, however, a similar level of advance notice may not be possible.

Aggregators and project participants shall not be made aware, in advance, of which fields' annual monitoring reports will be subject to desk-audit verification in a given year.

Regardless of the size of an aggregate, if the aggregate contains any fields that did not pass site-visit verification the year before and wish to re-enter the aggregate, 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 Sections 8.2.1, 8.2.2, and 8.2.3.

For the purposes of verification, a "small aggregate" is defined as an aggregate comprised of 10 or fewer fields, regardless of the number of project participants. Small aggregates will meet fixed site-visit and desk-audit verification frequency requirements based on a verification schedule determined by the verifier, in compliance with section 8.2.1 of this protocol.

A "large single-participant aggregate" is defined as an aggregate comprised of more than 10 fields all managed by one single project participant. For large single-participant aggregates, fields will be randomly selected for site-visit and desk-audit verification, according to the sampling method in Section 8.2.2, which is based on a non-linear scale where the relative fraction of fields undergoing verification activities gets smaller as the aggregate size gets larger.

A "large multi-participant aggregate" is defined as an aggregate comprised of more than 10 fields and more than one project participant. For large multi-participant aggregates, participants and their fields will be randomly selected for site-visit and desk-audit verification, according to the sampling method in Section 8.2.3, which is based on a non-linear scale where the relative fraction of participants undergoing verification activities gets smaller as the aggregate size in terms of number of participants gets larger.

In all cases, when determining the sample size for site visit and desk audits, the verifier shall roundup to the nearest whole number.

The actual requirements for performing a site-visit verification and desk-audit verification are the same. A desk audit is equivalent to a full verification, without the requirement to visit the site. A verifier has the discretion to visit any site in any reporting period if the verifier determines that the risks for that field warrant a site visit.

8.2.1 Verification Schedule for Small Aggregates

8.2.1.1 Site-Visit Verification Schedule for Small Aggregates

Each field in a small aggregate shall undergo an initial site-visit verification within the first two cultivation cycles for each crediting period. In the first year of the aggregate or in subsequent years when new fields enter the aggregate, a minimum of 30% of the newly enrolled fields shall complete the initial site-visit verification in their first year of enrollment.

In addition, site-visit verifications must be conducted on a schedule such that:

1. Each field in the aggregate must successfully complete a minimum of two site-visit verifications per crediting period (e.g. the initial site-verification in addition to one more).
2. A minimum of 20% of the fields in the aggregate shall be site-verified in any given year, selected at random.

8.2.1.2 Desk-Audit Verification Schedule for Small Aggregates

In any given year, a number of desk-audits of Field Monitoring Reports (FMR) must be conducted, with the number inversely related to the number of fields undergoing a site-visit that year. Specifically, the number of desk audits shall equal 50% of the number of fields in the aggregate that will not receive a site-visit that year, rounding up in the case of an uneven number of fields. In other words,

$$D = (n - S) / 2$$

Where:
n = the number of fields in the aggregate
S = the number of site visits
D = the number of desk audits

Fields shall not be selected for a desk-audit in years that the field is undergoing a site-visit. If a site-visit is planned for a field randomly selected for a desk-audit, the verifier will continue randomly drawing additional fields until the total number selected for a desk-audit reaches the value of D per the equation above.

8.2.2 Verification Schedule for Large Single-Participant Aggregates

In contrast to small aggregates, it is possible that a field in a large aggregate is never verified, either via site-visit or desk-audit, during its entire crediting period. Therefore, random sampling is a particularly important component of enforcement.

8.2.2.1 Sampling for Site-Visit Verification for Large Single-Participant Aggregates

The verifier determines the number of enrolled fields that must be randomly selected for site-visit verification in a given year. The required number of site-visits (S) shall equal the square root of the total number of fields enrolled in the large single-participant aggregate that year (i.e. S = sqrt (n)), rounded up to the nearest whole number.

8.2.2.2 Sampling for Desk-Audit Verification for Large Single-Participant Aggregates

In addition to site visit verifications, verifiers shall randomly select a sample of fields to undergo a desk audit (D) equal to two times the square root of the total number of fields in the aggregate. Fields shall not be selected for a desk-audit in years that the field is undergoing a site-visit. If a site-visit is planned for a field randomly selected for a desk-audit, the verifier will continue randomly drawing additional fields until the total number selected for a desk-audit reaches the square root of the total number of fields in the aggregate.

8.2.3 Verification Schedule for Large Multi-Participant Aggregates

The random sampling methodology shall be applied first at the project participant-level and then at the field-level. A random sampling methodology will be applied for site-visit and desk-audit selection. However, the verifier shall select fields for site-visits first as described in Section 8.2.3.1 and desk audits second, as described in Section 8.2.3.2.

In contrast to small aggregates, it is possible that a field in a large aggregate is never verified, either via site-visit or desk-audit, during its entire crediting period. Therefore, random sampling is a particularly important component of the enforcement mechanism.

8.2.3.1 Sampling for Site-Visit Verification for Large Multi-Participant Aggregates

1. First, the verifier shall determine the number of project participants that must be randomly selected for a site-visit in a given year, as follows:

S = (1 + (P/500))*sqrt(P) (rounded up to the nearest whole number)

Where:
P = the number of project participants in the aggregate
S = the number of site visits required

2. Second, the verifier shall randomly select *S* project participants to receive site-visits that year.

3. Next, the verifier shall select which fields of the selected project participants' will receive a site-visit. For project participants with six enrolled fields or fewer, the verifier shall site-visit at least 50% of the fields, selected at random. For project participants with more

than six fields enrolled in the aggregate, the verifier shall site-visit at least 33.3% of the fields, selected at random.

4. A minimum of the square root of the total number of fields in the aggregate must be site visited. If this number is not met after following steps 1-3, then the verifier shall randomly select one additional project participant and the sample of fields, according to Step 2 and 3 above, and repeat this until the number of site visits meets this minimum requirement. Note that Step 3 must be completed in full and therefore could result in a greater number of fields selected for site visits than the minimum requirement.

8.2.3.2 Sampling for Desk-Audit Verification for Large Multi-Participant Aggregates

In addition to site visit verifications, each year verifiers shall also randomly select fields to undergo a desk audit of their monitoring report. Verifiers shall randomly select a sample of fields to undergo a desk audit equal to two times the square root of the total number of fields in the aggregate (rounded up to the next whole number).

Fields shall not be selected for a desk-audit in years that the field is undergoing a site-visit. If a site-visit is planned for a field randomly selected for a desk-audit, the verifier will continue randomly drawing additional fields until the total number selected for a desk-audit reaches the square root of the total number of fields in the aggregate.

8.3 Standard of Verification

The Reserve’s standard of verification for RC projects is the RC Project Protocol (this document), and the Reserve Program Manual and Verification Program Manual. To verify a RC project aggregate, verification bodies apply the guidance in the Verification Program Manual and this section of the protocol to the standards described in 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.

8.4 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 by the aggregator and all enrolled fields. Verification bodies shall confirm that the Monitoring Plan covers all aspects of monitoring and reporting contained in this protocol and specifies how data for all relevant parameters in Table 6.1 are collected and recorded.

8.5 Verifying Eligibility at the Field Level

Verification bodies must affirm each project field’s eligibility during site visit and/or desk audit verifications according to the rules described in this protocol. The table below outlines the eligibility criteria for each project field. This table does not present all criteria for determining eligibility comprehensively; verification bodies must also look to Section 3 and the verification items list in Table 8.2.

Table 8.1. Summary of Eligibility Criteria for a Rice Cultivation Project

Eligibility Rule	Eligibility Criteria	Frequency of Rule Application
Start Date	The first day of the 'cultivation cycle,' which begins immediately after completion of a rice crop harvest, in which one or more of the approved project activities is adopted at the field. For 12 months following the Effective Date of this protocol, a pre-existing field with a start date on or after September 01, 2009 may be submitted for listing; after this 12 month period, projects must be submitted for listing within 6 months of the project start date	Once during first verification
Location	Approved Rice Growing Regions in the United States and U.S. tribal areas	Once during first verification
Anaerobic Baseline	All fields must demonstrate that previous rice cultivation practices resulted in anaerobic conditions	Once during first verification
Performance Standard	The field passes the Performance Standard Test for at least one of the approved project activities	Every verification
Legal Requirement Test	Signed Aggregator's Attestation of Voluntary Implementation form and monitoring procedures for ascertaining and demonstrating that the project passes the Legal Requirement Test	Every verification
Legal Title to CRTs	Aggregator Attestation of Title to CRTs	Every verification
Regulatory Compliance Test	Signed Attestation of Regulatory Compliance form and disclosure of all non-compliance events to verifier; project must be in material compliance with all applicable laws	Every verification

8.6 Core Verification Activities

The RCPP provides explicit requirements and guidance for quantifying the GHG reductions associated with the implementation of approved RC management practice changes on project fields. 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 an RC 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 for each Field

The verification body reviews for completeness the sources, sinks, and reservoirs identified for a project aggregate, ensuring that all relevant secondary effect SSRs for each field are identified.

Reviewing GHG management systems and estimation methodologies at the Field Level
The verification body reviews and assesses the appropriateness of the methodologies and management systems that are used to gather data and calculate baseline and project emissions for each field.

Reviewing GHG management systems and estimation methodologies at the Aggregate Level
The verification body reviews and assesses the appropriateness of the methodologies and management systems that the project Aggregator uses to gather data and calculate baseline and project emissions on the aggregate level.

Verifying emission reduction estimates at the Field Level
The verification body further investigates areas that have the greatest potential for material misstatements and then confirms whether or not material misstatements have occurred for all fields undergoing verification. This involves site visits to a random sample of project fields, according to the sampling methodology outlined in Section 8.1.2.1, to ensure the systems on the ground correspond to and are consistent with data provided to the verification body, combined with a random sample of desk review audits of remaining project fields per Section 8.2.2.2. In addition, the verification body recalculates a representative sample of the performance or emissions data from fields for comparison with data reported by the project aggregator in order to double-check the calculations of GHG emission reductions.

Verifying emission reduction estimates at the Aggregate Level
The verification body further investigates areas that have the greatest potential for material misstatements at the aggregate level, including that the appropriate modeling structural uncertainty factors (Section 5.1.7) and yield-loss statistical tests (Section 5.2.3) have been performed for the aggregate.

8.7 Project Type Verification Items

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

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

8.7.1 Project Eligibility and CRT Issuance

Table 8.2 lists the criteria for reasonable assurance with respect to eligibility and CRT issuance for RC project aggregates. These requirements determine if the aggregate is eligible to register with the Reserve and/or have CRTs issued for the reporting period. If any one requirement is not met, either the one or more fields, or the entire aggregate may be determined ineligible, or the GHG reductions from the reporting period (or sub-set of the reporting period) may be ineligible for issuance of CRTs, as specified in Section 3.

Table 8.2. Eligibility Verification Items

Protocol Section	Eligibility Qualification Item	Apply Professional Judgment?
2.2	Verify that all verified fields meet the definition of an RC project	No
2.3	Verify ownership of the reductions by reviewing Aggregator's Attestation of Title	No
2.3	Verify ownership of the reductions by reviewing Letters of Notification and contracts between Aggregators, Project Participants, and Land Owners	No
3.2	Verify project start date for all fields	No
3.2	Verify accuracy of project start date for all verified fields based on operational records	Yes
3.3	Verify that each field is within the 5 year crediting period (or a subsequent 5 year crediting period)	No
3.4	Verify that the management records at each verified field are adequate to document the anaerobic baseline requirements	No
3.5	Verify that the all verified fields have an SOC content less than 3% in the top soil.	No
3.6.1	Verify that each field meets the performance standard test	No
3.6.2	Confirm execution of the Attestation of Voluntary Implementation form to demonstrate eligibility under the Legal Requirement Test	No
6.1	Verify that the project Aggregate Monitoring Plan contains a mechanism for ascertaining and demonstrating that all fields pass the Legal Requirement Test at all times	No
3.6	Verify that the project activities at all verified fields comply with applicable laws by reviewing any instances of non-compliance provided by the aggregator and performing a risk-based assessment to confirm the statements made by the project developer in the Attestation of Regulatory Compliance form	Yes
6.1, 6.2	Verify that the field level and aggregate level monitoring meets the requirements of the protocol. If it does not, verify that variance has been approved for monitoring variations	No

8.7.2 Quantification

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

Table 8.3. Quantification Verification Items

Protocol Section	Quantification Item	Apply Professional Judgment?
4	For each field, verify that all SSRs in the GHG Assessment Boundary are accounted for, particularly Secondary Effect Emissions	No
5.1.1	For each field, verify that the Project Parameters and the Static Parameters are represented by the appropriate data and the DNDC input files are accurate for the baseline modeling and the project modeling	Yes
5.1.2	For each field, verify that the DNDC model is adequately calibrated to	Yes

Protocol Section	Quantification Item	Apply Professional Judgment?
	historical yields, and that the 20 year historical calculation was run correctly	
5.1.4, 5.1.5	For each field, verify that the baseline and project emission models have the same static parameters, and that the project model adequately represents the project activities during the cultivation cycle	No
5.1.3, 5.1.4, 5.1.5	For each field, verify that the Monte Carlo analysis was performed correctly for the baseline and project modeling runs for each field	No
5.1.6	For each field, verify that the input uncertainty discount is quantified and applied correctly	No
5.1.7	For the aggregate, verify that all field emission reductions are summed correctly, and that the structural uncertainty factor is properly applied	No
5.2.2	For each field, verify that baled rice straw end-uses are properly characterized, and the appropriate emission factors are used	Yes
5.2.1	Verify that the aggregator correctly monitored, quantified and aggregated fossil fuel and electricity use changes	Yes
5.2.3	For the aggregate, verify that the statistical test for reduced yield is properly performed, and that increased emissions outside the project boundary are properly quantified for significant yield losses	No

8.7.3 Risk Assessment

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

Table 8.4. Risk Assessment Verification Items

Protocol Section	Item that Informs Risk Assessment	Apply Professional Judgment?
6.1, 6.2	Verify that the project has documented and implemented the Aggregate Monitoring Plan, and all necessary Field Monitoring Plans.	No
6.1,6.2	Verify that the project Monitoring Plans are sufficiently rigorous to support the requirements of the protocol and proper operation of the project	Yes
6.2.3	Verify that appropriate monitoring data is measured, or referenced accurately	No
6,7	Verify that the individual or team responsible for managing and reporting project activities are qualified to perform this function	Yes
6,7	Verify that appropriate training was provided to personnel assigned to greenhouse gas reporting duties	Yes
6	Verify that all contractors are qualified to perform the duties expected. Verify that there is internal oversight to assure the quality of the contractor's work	Yes
7	Verify that all required records have been retained by the project developer	No

8.8 Successful and Unsuccessful Verifications

Successful verification of each field in the sample of fields selected for site visit and desk audits results in the crediting of all fields participating in the entire project aggregate, as calculated by the aggregator according to the quantification methodology in Section 5.

Verification may uncover any number of material and immaterial errors at the field-, project participant- or aggregate-level, and the extent to which an error was propagated through the aggregate can affect whether a verification is determined to be "unsuccessful."

8.8.1 Field-Level and Project Participant-Level Errors

If material issues arise during verification of a participating field, verifiers shall issue Corrective Action Requests, as needed. The aggregator will need to work with the project participant to independently address the issues and required corrective actions using the same process taken with standalone projects. These are described in the verification guidance of this protocol and the Reserve Verification Program Manual. If the error can be corrected at the field-level and is the type of error which will not be propagated across an individual participant's fields or the entire aggregate, then the error shall be corrected and the field's verification shall be considered successful. Errors shall be considered immaterial at the field-level if they result in a discrepancy that is less than 5% of the total emissions reductions quantified for that field.

If verification of a field reveals material non-compliance with the protocol, and no corrective action is possible, that field shall receive a negative verification and no CRTs shall be issued for that field, effectively removing the field from the aggregate for that year. When verification is unsuccessful for a participating field, the verifier must verify additional fields until the total number of successful verifications reaches the required number (as described in section 8.2), starting with fields managed by the same participant as follows. If the project participant managing the unsuccessfully verified field also manages other fields enrolled in the aggregate, the verifier shall site-visit a minimum of 2 additional fields or 50% of the remaining unverified fields, whichever is larger, that are managed by that project participant. If the verification of the additional fields is also unsuccessful, no CRTs shall be issued for any of the fields managed by the project participant.

Deliberate non-compliance may result in disqualification of the project participant including all of their enrolled fields. Additionally, if the project participant failing verification and his/her negatively verified fields re-enter the aggregate the following year, each of the fields that failed verification the previous year shall be required to undergo a site visit, in addition to the minimum sampling requirements in Section 8.2.

Whenever a project participant receives a negative verification for all of their enrolled fields, the verifier shall use their professional judgment and a risk based assessment on determining whether sampling additional project participants for site-visit verification, beyond the minimum requirements of this protocol, are necessary to verify the entire aggregate to a reasonable level of assurance.

8.8.1.1 Cumulative Field-Level Error of Sampled Fields

Total errors and/or non-compliance shall be determined for the sampled fields, and the offset issuance for those fields corrected, as required by the VPM. Should the aggregated error and/or non-compliance rate for these sampled fields be less than 5%, CRT issuance for fields not subjected to site-visit or desk-review verification shall be equal to the amount reported by the aggregator. However, if the aggregated percent error and/or non-compliance rate (i.e. the percentage of verified fields failing verification) for sampled fields is greater than 5%, CRT issuance for fields not subjected to site-visit or desk-review verification shall be reduced by the total amount of aggregated percent error or non-compliance rate.

8.8.2 Aggregate-Level Errors

If verification reveals a potential systemic error, which may be propagated out to the aggregate-level (e.g. a qualitative error with regards to the models input parameters or a quantitative error repeated in multiple field-level model runs), the verifier shall use their professional judgment to sample additional fields, as necessary, to determine whether the error is truly systemic. Systemic errors must be corrected at the Aggregate-level.

8.9 Completing Verification

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

9 Glossary of Terms

Accredited verifier	A verification firm approved by the Climate Action Reserve to provide verification services for project developers.
Additionality	Organic waste management practices that are above and beyond business-as-usual operation, exceed the baseline characterization, and are not mandated by regulation.
Anaerobic	Pertaining to or caused by the absence of oxygen.
Anthropogenic emissions	GHG emissions resultant from human activity that are considered to be an unnatural component of the Carbon Cycle (i.e. fossil fuel destruction, de-forestation, etc.).
Biogenic CO_2 emissions	CO_2 emissions resulting from the destruction and/or aerobic decomposition of organic matter. Biogenic emissions are considered to be a natural part of the Carbon Cycle, as opposed to anthropogenic emissions.
Carbon dioxide (CO_2)	The most common of the six primary greenhouse gases, consisting of a single carbon atom and two oxygen atoms.
CO_2 equivalent (CO_2e)	The quantity of a given GHG multiplied by its total global warming potential. This is the standard unit for comparing the degree of warming which can be caused by different GHGs.
Direct emissions	Greenhouse gas emissions from sources that are owned or controlled by the reporting entity.
Effective Date	The date of adoption of this protocol by the Reserve board.
Emission factor (EF)	A unique value for determining an amount of a greenhouse gas emitted for a given quantity of activity data (e.g. metric tons of carbon dioxide emitted per barrel of fossil fuel burned).
Fossil fuel	A fuel, such as coal, oil, and natural gas, produced by the decomposition of ancient (fossilized) plants and animals.
Greenhouse gas (GHG)	Carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), sulfur hexafluoride (SF_6), hydrofluorocarbons (HFCs), or perfluorocarbons (PFCs).
GHG reservoir	A physical unit or component of the biosphere, geosphere, or hydrosphere with the capability to store or accumulate a GHG that has been removed from the atmosphere by a GHG sink or a GHG captured from a GHG source.
GHG sink	A physical unit or process that removes GHG from the atmosphere.
GHG source	A physical unit or process that releases GHG into the atmosphere.

Global Warming Potential (GWP)	The ratio of radiative forcing (degree of warming to the atmosphere) that would result from the emission of one unit of a given GHG compared to one unit of CO_2.
Indirect emissions	Reductions in GHG emissions that occur at a location other than where the reduction activity is implemented, and/or at sources not owned or controlled by project participants.
Metric ton or “tonne” (MT)	A common international measurement for the quantity of GHG emissions, equivalent to about 2204.6 pounds or 1.1 short tons.
Methane (CH_4)	A potent GHG with a GWP of 21, consisting of a single carbon atom and four hydrogen atoms.
Mobile combustion	Emissions from the transportation of materials, products, waste, and employees resulting from the combustion of fuels in company owned or controlled mobile combustion sources (e.g. cars, trucks, tractors, dozers, etc.).
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.
Stationary combustion source	A stationary source of emissions from the production of electricity, heat, or steam, resulting from combustion of fuels in boilers, furnaces, turbines, kilns, and other facility equipment.
Verification	The process used to ensure that a given participant’s greenhouse gas emissions or emission reductions have met the minimum quality standard and complied with the Reserve’s procedures and protocols for calculating and reporting GHG emissions and emission reductions.
Verification body	A Reserve approved firm that is able to render a verification opinion and provide verification services for operators subject to reporting under this protocol.

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Appendix A Parameter Look-Up Tables

Rice Straw End-Use	Emission Factor ($MTCO_2e$/MT baled straw)
Unknown or 'other' off-site management	0.065 [1]
Animal Bedding	0 [2,3]
Dairy and Beef Cattle Feed	0.063 [2,4]
Fiberboard manufacturing	0 [5]
Spread on Bare Soils for Erosion Control	0.070 [6]
Unused, left piled onsite	0.210 [7]

1. Using survey responses from California rice baling experts, end-use emissions factors were determined for each of the expert's estimates of the current rice straw end-use market. The most conservative estimate was used for this emissions factor. The scenario used estimates that 75% of rice straw goes to Dairy and Beef Cattle feed, with the remainder going to Erosion Control. Negligible amounts go to other end-uses.
2. Rice straw replaces other straw products transported from a comparable distance; therefore transportation emissions are not included.

3. Decay of rice straw will likely occur under aerobic conditions

4. Change in enteric emissions may occur due to low nutritional quality of rice straw. It is assumed for conservativeness that the enteric CH_4 conversion factor is increased by 1% due to switching to low-digestible food (2006 IPCC Guidelines for National Greenhouse Gas Inventories, Vol. 4, Pg. 10.30). Emission factor assumes a calorific value of dry rice straw of 15 MJ/kg (Putun et al., 2004), and a energy content of methane of 55.65 MJ/kg (2006 IPCC Guidelines for National Greenhouse Gas Inventories, Vol. 4, Pg. 10.32)

5. Rice straw replaces wood products for manufacturing of fiber board. Avoidance of harvesting and transport of wood products provides likely net-positive GHG benefits.

6. Because options for erosion control are numerous, transportation emissions and emissions from spreading must be accounted for. Emission factor assumes 1.5 Gallons of diesel per acre for spreading (equal to fuel use assumed for chopping and disking). Emissions factor from storing, loading, transporting straw assumes use of 11 Gallons diesel per acre..

7. Equal to the IPCC Default emission factor for

aerobic composting (0.10 kg CH_4/MT input). Low nitrogen residues (such as rice straw) would have discounted emission fugitive emissions compared with other compostable organic residues (Brown et al., 2008).	

Appendix B DNDC Model Users Guide

This will focus on using DNDC for quantifying changes in GHG emissions through a change in management practices. Users can also refer to the DNDC Users Guide that is available for download.

[TO BE PROVIDED WITH FINAL PROTOCOL]

Appendix C Summary of DNDC Model Validation and Uncertainty Analysis

Determining Structural Model Uncertainty and Deductions

Basic Assumptions Underlying Uncertainty Deductions

- The structural error induced by a biogeochemical model such as DNDC is multiplicative, not additional:

$$Y_{field,i} = Y_{model,i} \cdot \varepsilon_i$$

  The multiplicative nature of the deviation between modeled and measured results originates from increasing deviations with increasing modeled values. This assumption is generally valid when moderate changes to input data lead to moderate changes in the results of the biogeochemical model and no sudden non-linear changes exist. Under the applicability conditions of the methodology, the DNDC model will react linearly to moderate changes in input data.
- No bias exists between measured and modeled results, so that $\langle Y_{field} \rangle = \langle Y_{model} \rangle$. In addition, the error ε is log-normally distributed, $\varepsilon \sim \ln \mathcal{N}(0, \sigma)$. The DNDC model has been shown to predict greenhouse fluxes without bias, when correctly calibrated. This methodology specifies how model inputs can be set so that the model is calibrated correctly. It must be explicitly tested that the model calibration strategy does not lead to bias.
- Model results of an alternative treatment are 100% correlated with the model results of the baseline treatment:

$$Y_{field,project} = k \cdot Y_{field,baseline}$$

Where k is dependent on all factors that were not impacted by the project. In other words, changes in emissions due to weather or other static variables are similar between project and baseline scenarios, apart from a linear constant.

Procedure used to Calculate the Structural Uncertainty Deduction Factor

Since the structural error is multiplicative, the residual of the log-transformed field and measured results is normally distributed:

$$\ln (Y_{field}) - \ln (Y_{model}) \sim \mathcal{N}(0, \sigma)$$

Assume that n is the number of $(Y_{field,i}, Y_{model,i})$ pairs, σ can be estimated as:

$$s = stdev\left(\ln (Y_{field,i}) - \ln (Y_{model,i})\right)$$

Since σ is not known, traditional statistical theory dictates that confidence and prediction intervals need to be estimated based on the student t-distribution with n degrees of freedom. We are interested in the effect of taking averages of individual fields on the decrease in the uncertainty. However, since the sum of different student t-distribution does not have an easy analytical form, we will assume that the error σ is normally distributed. In this case, the 95%-confidence prediction interval becomes:

$$[-s \cdot \phi(0.025); +s \cdot \phi(0.975)]$$

In case one is looking at the average of m field measurements, the 95%-confidence prediction interval around the m measurements becomes:

$$\left[\frac{-s}{\sqrt{m}} \cdot \phi(0.025); \frac{+s}{\sqrt{m}} \cdot \phi(0.975)\right]$$

The discounting factor u_{struct} must be set so that, with 95% confidence:

$$u_{struct} \cdot \left(Y_{model,alternative} - Y_{model,baseline}\right) < Y_{field,alternative} - Y_{field,baseline}$$

Using assumption 2, this comparison can be simplified as following

$$u_{struct} \cdot Y_{model,baseline} \cdot (1-k) < Y_{field,baseline} \cdot (1-k)$$
$$u_{struct} \cdot Y_{model,baseline} < Y_{field,baseline}$$

After taking a logarithm and rearranging:

$$\ln(u_{struct}) < \ln\left(Y_{field,baseline}\right) - \ln\left(Y_{model,baseline}\right)$$

The discounting factor for structural uncertainty is therefore:

$$u_{struct} = \mathrm{e}^{\frac{-s}{\sqrt{m}} \cdot \phi(0.025)}$$

Derivation of Structural Uncertainty Deduction for California Projects

Nine different annual fluxes of CH_4 emissions were measured for a number of different management scenarios. The same practices were modeled using the DNDC model. These scenarios represent the variety of management practices that is covered by this methodology. Results from this exercise are summarized in Table C.1. Further details can be found in EDF (2011).

Table C. 1. Modeled and Measured CH_4 Fluxes from Field Trials in California

Seeding	Tillage	Winter Flooding	Residue	Modeled kg CH_4-C ha^{-1}	Measured
Water	Conventional	Yes	incorporation	121	130
Water	Conventional	Yes	burn	56	52
Water	Conventional	No	incorporation	68	75
Water	Conventional	Yes	incorporation	166	273
Water	Conventional	Yes	burn	56	57
Water	Conventional	Yes	incorporation	71	165
Water	Conventional	N/A (GHG measurements were only for in-season emissions)	N/A, no GHG measurements after residue management	465	354
Water	Stale seedbed (essentially no-till	N/A (GHG measurements were only for in-season	N/A, no GHG measurements	417	390

	prior to plant)	emissions)	after residue management		
Dry	Conventional.	N/A (GHG measurements were only for in-season emissions)	N/A, no GHG measurements after residue management	254	229

Source: Data Reproduced with Permission from EDF (2011).

The average of the natural logarithm of the deviations between measured and modeled fluxes is 0.112; the standard deviation is 0.346.Using the equation above, the appropriate discounting factors can be calculated, therefore, as following:

$$u_{struct}(m) = \mathrm{e}^{\frac{-0.346}{\sqrt{m}} \cdot 1.96}$$

Table 5.7 summarizes the results of this equation. This methodology requires that a minimum of five fields (or 1000 acres) be included. This minimum of 5 required fields corresponds to an uncertainty deduction of 26%. In conclusion, the maximal structural uncertainty deduction is 26%.

Appendix D Summary of Performance Standard Research

This section summarizes research on industry trends in the use of water and residue management practice in rice cultivation that have the potential to reduce methane emissions. The research focused on three practices that had previously been identified in other methodologies as having GHG mitigation potential: dry seeding, reduced winter flooding, and residue management. The outcomes of the research were used to develop performance standards in this protocol.

Background on Water and Residue Management Practices

Rice is a unique agricultural system due to the use of flooding to meet the plant physiological demands and to control weeds. There are unique advantages of flooding and maintaining a flood throughout the growing season. These advantages include: "(1) easier water management and less water use, (2) red rice and grass suppression, (3) less seedling stress from cool weather, (4) elimination of early-season blackbird problems, (5) reduction in seedling loss due to salt, and (6) increased nitrogen efficiency, when nitrogen is applied to dry soil before floodin

Producers decisions regarding which seeding method to use are targeted at selecting the method that will result in proper seedling emergence that will lead to a uniform canopy Seeding methods depend on soil type, weather conditions, and producer preferences. Seeding methods for rice production include both water seeding and dry seeding. **Water seeding** describes sowing of dry or soaked seed into a flooded field. It is usually implemented for any or all of the following reasons: red rice control, wet planting season, planting efficiency and earlier crop maturity. **Dry seeding** simply describes sowing seed into a dry seedbed by drilling or broadcasting. Dry seeding method usually offers more flexibility in planting but may require more time to do so. The flood for dry seeded rice starts approximately 25 days after seeding. During the dry period, fields are periodically irrigated to promote germination and stand establishment. This system is also weather dependent. A small fraction of the rice acreage is dry seeded in California.

In California, water seeding with continuous flood is predominant during the growing season.. Continuous flood regime is used on over 96% of the acreage in California. Fields are flooded to a depth of 4-5 inches just prior to aerial seeding. While deeper flooding will further reduce weed pressures, it will also lead to poor stand establishment. Once the rice stand is established and the panicle initiation has occurred, many growers will increase the depth of the flood water to 8 inches. This helps with further weed control and protects the rice reproductive organs from cool nighttime temperatures that can lead to reduced yields via blanking. Occasionally, several weeks after seeding, fields are drained for one day to apply herbicide for weed control. This drain is short lived and does not lead to drying of the soil surface. Fields are also drained near the harvest date. The exact timing of the draining the fields vary and can influence total yields.

UCCE recommends grower drain their fields when the panicles are "fully tipped and golden". This is done through visual inspection. This is typically 2-4 weeks prior to anticipated harvest date. According to UCCE extension, there is a large variability in when growers choose to drain the fields. Some growers choose to drain when the rice is partially or 50% "tipped", some wait until 75% tipped and others follow UCCE guidelines of 100% or fully tipped.

After the growing season, winter flooding can be used to enhance rice straw decomposition. With a winter-flood system that the floodwater is introduced to the field shortly after harvest is completed. Growers either maintained flooded conditions until spring by reapplying flood waters or just use a single flood event. Grower's decisions to flood the field after harvest are influenced by timing of the harvest, habitat goals and expectations regarding availability of water (Term 91).

Industry Trends in the Use of GHG Mitigating Practices

Winter Flooding

Two sources of data were used to characterize the use of winter flooding in California rice systems. Site specific records on the use of winter flooding were collected from the following four irrigation districts: Glen-Colusa, RD 108, Richvale and Western Canal. In addition, multi-temporal remote sensing data (MODIS and Landsat) were analyzed to map spatial patterns of winter flooding from 2005 to 2010 for the entire California Sacramento Valley.

The data from the Glenn-Colusa Irrigation District (represents over 20% of California rice acreage) were analyzed in a GIS to assess acreage of winter flooding from 2007 to 2010 and persistence of winter flooding from one year to the next for each rice field.. Approximately 40% of the fields did not use winter flooding from 2007 to 2010 (Table A-1). Of the 60% of the fields that did use winter flooding at some point, less than 1% of the fields winter flooded for all 4 years. The data from the other irrigation districts (RD108, Richvale and Western Canal) showed similar variability in the fraction of fields with winter flooding.

Table A-1: Presence and Frequency of Winter Flooding in Glenn-Colusa Irrigation District (2007-2010).

Class	Acreage	%
No Floods	42161.9	40.0%
1 Yrs	20314.3	19.3%
2 Yrs	22346.9	21.2%
3 Yrs	17566.9	16.7%
4 Yrs	1912.6	1.8%
Other	977.4	0.9%

In addition, we analyzed multi-temporal remote sensing data (MODIS and Landsat) to map spatial patterns of winter flooding for rice growing areas for all of California from 2005 to 2010. These results also indicated that the use of winter flooding varies from one year to the next and there is no clear trend in the extent and frequency of use of winter flooding for all rice growing regions. Details of the spatial analysis of winter flooding are provided in a separate background research paper that will be published on the Reserve Website.

The results of this research show that the use of winter flooding every year is virtually non-existent; it is more typical for winter flooding to be used one, two or three years out of every five years with no winter flooding the other years; and 40% of acres appear to never be flooded during the 5 year interval investigated. Data reported in the background paper affirm these same findings over a longer historical period. Therefore, reduced winter flooding (i.e. the absence of winter flooding) is already somewhat common in the California Sacramento Valley. In addition, the intermittent trend in use/non-use of winter flooding, make it difficult to reliably determine what expected levels of reduced winter flooding would be any given year under business as usual. These findings combined with concerns about negative impacts on waterfowl habitat let to a decision exclude reduced winter flooding as an eligible project activity in the protocol.

Rice Straw Residue Management

Rice straw represents a significant challenge to rice farmers. Techniques for managing rice straw can be categorized in to the following management alternatives: burning, baling, soil incorporation without winter flooding and soil incorporation with winter flooding for enhanced straw decomposition.

Rice straw may or may not be prepared by chopping or soil incorporating before flooding. After flooding, many fields are rolled with specially built "cage rollers" which help create soil/straw contact. Decomposition of straw in this system is not limited by moisture and has consistently given more complete decomposition compared to non-flooded systems.

Most potential uses of rice straw can be categorized into energy use, manufacturing and construction, environmental mitigation or livestock use. Environmental mitigation uses include the use of rice straw for erosion control on construction areas or for rehabilitation on burned slopes. Small amounts of rice straw are used in composting, mushroom production, and livestock feed and bedding.

There are many potential uses of rice straw yet few are currently being used. The reasons appear to be related to 1) technical constraints, 2) economic feasibility, particularly related to the cost of removing straw from the field, and supply and storage problems.

Until 1991, burning rice straw was the most common practice. The Following 1991 Rice Straw Burning Reduction Act, burning of rice straw decreased dramatically on an annual basis. By 2001 growing season burning of rice straw was permitted for disease control only with a cap of 25 percent of total rice acreage in the state burned annually. Currently, burning occurs on only 10-12 percent of rice acreage in California (personal communication with Paul Buttner).

If the straw is not burned, then growers will either retain and incorporate all of the straw on the field or they will bail the rice straw for off field uses. The current estimate from the California Rice Commission for baling in California is 6-8% of the acreage per year. This estimate was further corroborated by the Reserve through analysis of previous research[41], and through the use of a survey of University of California Cooperative Extension (UCCE) Rice Farm Advisors and straw balers in California. Results in the survey suggest that rice baling has declined in recent years due to a loss of demand form the building and construction industry. Estimates from UCCE Rice Advisors ranged from 2-6% of the California acreage in a given year. This obviously fluctuates a bit with various straw markets. It is also important to note that baling does not remove all of the rice straw following harvest. Due to operational constraints and the market for straw, baling typically removes 1-2 tons of rice straw per acre out of approximately 3 tons per acre that is produced. So anywhere from 50% to 33% of the rice straw remains on the field. On an annual basis 80-84% of all rice fields have 100% of the rice straw incorporated in to the soil.

Based on the evidence presented by California rice industry experts, the Reserve has concluded that baling of rice straw is not a common practice in California, with a likely adoption rate of between 2-7% of the acreage. Thus, the Reserve has concluded that switching from rice straw incorporation to baling constitutes an additional GHG reduction practice in California.

[41] Garnache et al. 2011.

Dry Seeding

According to the USDA ERS data analyzed by Livezey et al. in 2001, a dry seeding method is relatively common in most U.S. rice growing regions; however it is not common practice in California. In 2001, the estimated acreage of rice that was dry seeded was 5% according to the ERS data.[42] To confirm that dry seeding is still not a common practice in California, the Reserve again relied on the estimates provided in survey responses from UCCE Rice Farm Advisors, as well as estimates from the California Rice Commission. According to experts from the UCCE and CalRice, dry seeding is occurring on *less than* 3% of the rice acreage in California. Based on the evidence presented by California rice industry experts, the Reserve has concluded that baling of rice straw is not a common practice in California, with a likely adoption rate of between 2-7% of the acreage. Thus, the Reserve has concluded that switching from rice straw incorporation to baling constitutes an additional GHG reduction practice.

Based on the evidence presented by California rice industry experts, the Reserve has concluded that dry seeding is not a common practice in California, with a likely adoption rate of less than 3% of the acreage. Thus, the Reserve has concluded that switching from water seeding to dry seeding constitutes an additional GHG reduction practice in California.

[42] Livezy et al., (2001) Table 5, pg. 10.

Appendix E Wildlife Habitat Conservation and the Rice Industry

In California's Central Valley approximately 95% of the originally existing wetlands have been converted from their natural state. [43]

As native wetland habitats have been increasingly degraded, wetland-dependent species, such as waterfowl and shorebirds, have adapted to using flooded rice lands as a substitute for their native habita.t Rice fields may be flooded for up to eight months of the year, mimicking natural wetland conditions and providing surrogate habitat for foraging, breeding, and in the case of migratory birds, wintering.

Though a wide range of species can be observed in each of the U.S. rice growing regions, more species data are available for California's Central Valley than for other U.S. rice-growing regions. In California, 7 million waterfowl and several hundred thousand shorebirds are supported by rice lands annually,[44] and over 230 species have been identified in the state's rice lands, including waterfowl (e.g. ducks), shorebirds, wading birds, raptors, reptiles, amphibians, and small mammals.[45] Notably, 31 special-status species, such as the federally endangered Giant Garter Snake have also been identified in California rice lands.

In the U.S., rice lands are considered a leading example of integrating agricultural and natural resource management, with USDA recently honoring the USA Rice Federation with the first national "Legacy of Conservation" award in 2011.

The Reserve's Program Manual explains that generally "projects must have no negative social, economic or environmental consequences and ideally should result in benefits beyond climate change mitigation."

The adoption of dry seeding is expected to result in a delay in winter flooding by a few days, meaning that though there is a slight delay in the provision of surrogate habitat (e.g. flooded rice fields) to wetland-dependent species, the quality of the surrogate habitat will not be affected. The effect of baling on the quality of flooded rice lands as surrogate habitat is somewhat less clear. In one study of species preferences for different rice straw management options, wetland-dependent bird species appeared to have a slight preference for fields where rice straw had been left on the field (whether spread or incorporated) over fields where the rice straw residue had been removed (by baling).[46]

The Reserve will continue to monitor the impacts on wildlife habitat that result from the above two RC management changes, as well as other potential management changes that may be allowed in subsequent version of this protocol. Should it be determined that a certain activity is resulting with negative impacts, mitigation options and/or changes in approved project activities may be required under subsequent protocol versions.

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[43] Petrie et al (DU report).
[44] Petrie et al (DU report).
[45] Sterling et al.
[46] Elphick, Chris and Lewis Oring, "Conservation implications of flooding rice fields on winter waterbird communities," *Agriculture, Ecosystems, and Environment* 94 (2003).