U.S.
Rice Cultivation

Protocol | Version 1.1 | June 3, 2013

Errata + Protocol

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Rice Cultivation Project Protocol Version 1.1

ERRATA AND CLARIFICATIONS

The Climate Action Reserve (Reserve) published its Rice Cultivation Project Protocol Version 1.1 (RCPP V1.1) in June 2013. While the Reserve intends for the RCPP V1.1 to be a complete, transparent document, it recognizes that correction of errors and clarifications will be necessary as the protocol is implemented and issues are identified. This document is an official record of all errata and clarifications applicable to the RCPP V1.1.[1]

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

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

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

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

Errata and Clarifications (arranged by protocol section)

Appendix B Step 1.3

1. DNDC Climate Input Data File Formatting (ERRATUM – January 21, 2014)

Section: Appendix B, Step 1.3 DNDC Climate Input Parameters

Context: This step provides background information on the climate input parameters used to run the DNDC model and instructs project developers on how to enter data for these parameters into DNDC. Following an initial description of the climate input parameters and a bulleted list of requirements for determining climate parameter inputs, a paragraph outlines how to enter data into the model, beginning with the words “Data for N concentration in rainfall…” (page 77). The final sentence in that paragraph erroneously lists “Humidity” twice in the data file format. The same mistake is repeated in the example data layout provided in Table B.5. Humidity data should appear once in the series, as the final data input parameter.

Correction: The last sentence on page 77 should be amended to read: “In other words, data needs to be input in text files in the following order: Jday, MaxT, MinT, Precipitation, Wind Speed, Humidity.”

Table B.5 on page 78 should be amended to read as follows:

Table B.5. Required Formatting for Climate Input Files

Jday	MaxT (^oC)	MinT (^oC)	Precipitation (cm)	Wind Speed (m/s)	Humidity (%)
1	12.1	5.2	1.41	2.3	77
2	11.1	6.2	3.01	7.5	80
3	10.1	7.2	0.34	4.3	82
4	11.1	8.2	0.01	2.9	81

*NOTE: Only the format and data itself and not the text of a header row should be entered into the Climate Input files.

Appendix B Step 2.1

2. Missing Climate Data (CLARIFICATION – January 21, 2014)

Section: Appendix B, Step 2.1 Missing Climate or Soil Data

Context: The DNDC model will crash if instructed to run without a full set of data for each input parameter. This step provides a methodology for how to overcome missing climate or soil data. The guidance with respect to missing climate data does not address such instances where climate data are missing for a period not exceeding 14 days, in which a complete and continuous set of data from the 14 day period immediately prior to and following the data gap (for a total of 28 days) are also not available from the same source. In such circumstances, data from another source or the nearest alternative weather station must be used.

Clarification: The following text shall be inserted following the first sentence of the last paragraph on page 82, which begins with the words "For gaps in climate data that do not exceed 14 days…":

> "If a complete and continuous set of data for the 14 days preceding and following the data gap (for a total of 28 days) cannot be obtained from the same source, project developers must substitute data for the data gap from another source in that same region, and if such data are not available, project developers must then use data from the nearest alternative weather station."

U.S.

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Abbreviations and Acronyms

CDM	Clean Development Mechanism
CH_4	Methane
CO_2	Carbon dioxide
CRT	Climate Reserve Tonne
CSV	California Sacramento Valley
DNDC	Denitrification-Decomposition biogeochemical process model
DOC	Dissolved organic carbon
DS	Dry seeding
EPA	Environmental Protection Agency
GHG	Greenhouse gas
GUI	Graphical user interface
HCP	Habitat Conservation Plan
IPCC	Intergovernmental Panel on Climate Change
ISO	International Organization for Standardization
lb	Pound
MT (t)	Metric ton (or tonne)
N_2O	Nitrous oxide
NRCS	Natural Resources Conservation Service of the USDA
RC	Rice cultivation
Reserve	Climate Action Reserve
SOC	Soil organic carbon
SHA	Safe Harbor Agreement
SSR	Source, sink, and reservoir
UNFCCC	United Nations Framework Convention on Climate Change
USDA	United States Department of Agriculture

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 the most experienced, trusted and efficient offset registry to serve the California cap-and-trade program and the voluntary carbon market. With deep roots in California and a reach across North America, the Reserve encourages actions to reduce greenhouse gas emissions and works to ensure environmental benefit, integrity and transparency in market-based solutions to address global climate change. It operates the largest accredited registry for the California compliance market and has played an integral role in the development and administration of the state's cap-and-trade program. For the voluntary market, the Reserve establishes high quality standards for carbon offset projects, oversees independent third-party verification bodies and issues and tracks the transaction of carbon credits (Climate Reserve Tonnes) generated from such projects in a transparent, publicly-accessible system. The Reserve program promotes immediate environmental and health benefits to local communities and brings credibility and value to the carbon market. The Climate Action Reserve is a private 501(c)(3) nonprofit organization based in Los Angeles, California.

Project developers 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 project.

2 The GHG Reduction Project

2.1 Background

Methane (CH_4), a potent 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.[2] 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.
[2] Ibid.

2.1.1 Rice Cultivation Techniques

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

1. **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.
2. **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 three to five 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.
3. **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 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 remain flooded until the typical pre-harvest drain.

Producer 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.

1. **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.
2. **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.

2.1.2 California Rice Cultivation Practices

In California's Sacramento Valley rice growing region (see Figure 2.1 below), continuous flood is the dominant water management technique.[3] Fields are typically flooded to a depth of 4 to 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 recommends growers to drain their fields when the panicles

[3] Correspondence with Paul Buttner (CalRice).

are 100 percent “fully tipped and golden,” although fields are often drained earlier due to other contributing factors such as soil type (e.g. 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 percent of the acreage in California.[4] A small fraction of the rice acreage is dry seeded in California. The flood for dry seeded rice starts approximately 25 to 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 GHG emissions. Timing of straw amendment/incorporation can impact GHG emissions by altering the timing and availability of substrate (dissolved organic carbon or 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 prevailing management practice in California 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 to 12 percent of rice acreage in California.[5]

Some growers bale rice straw for off-field uses. The current estimate for baling adoption in California is 2 to 6 percent of California rice acres per year.[6] This fluctuates slightly coincident with the 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 about three 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 onsite. Presently, the majority of rice straw is sold for dairy heifer and beef cattle high roughage feed (estimated to be 75 to 85 percent), with some straw used for erosion control (15 to 25 percent), and very little sold for building construction. The straw that is baled and left onsite is typically composted in large static piles.

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

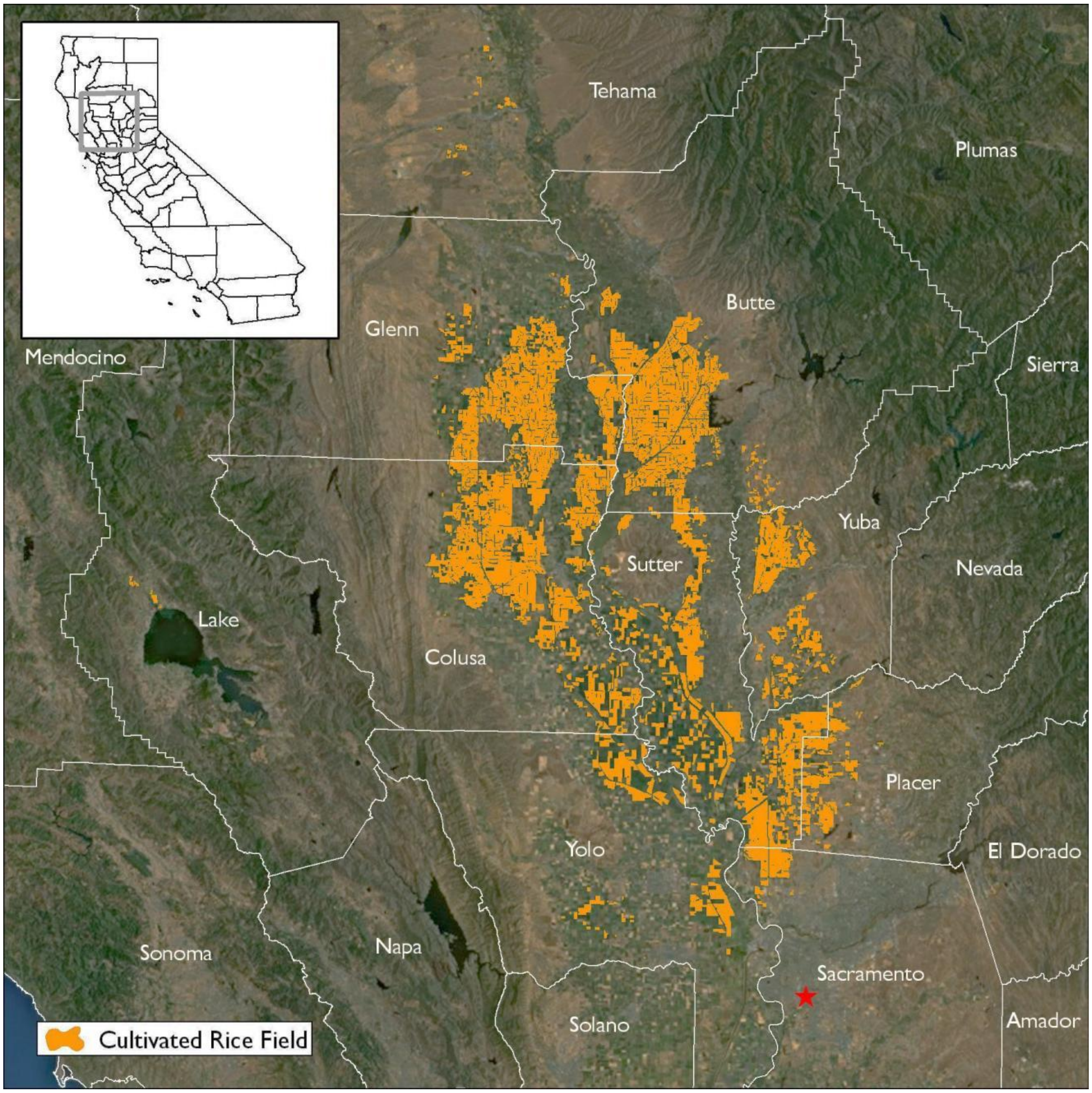

Figure 2.1. California's Sacramento Valley Rice Growing Region

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[7] 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 may be implemented on a single field, known as a "single-field project," or may be implemented on two or more individual fields combined into a single project area, known as a "project aggregate." Specific requirements for project aggregates are outlined in Section 2.4 below. Physical boundaries for individual fields must be defined according to the requirements in Section 2.2.1.

[7] 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.

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 (non-flooded[8]) soil with field flooding delayed until rice stand is established (typically 25 to 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 dissolved organic carbon 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.[9]	California

2.2.1 Defining Field Boundaries

For the purposes of quantifying emission reductions with this protocol, a field must be defined as an area of rice cultivation across which management practices are homogenous.[10] Thus if management practices differ across a single rice paddy, the paddy would need to be divided into multiple "fields" corresponding to different management practices for the purpose of this protocol.

An individual rice field must be defined by the following criteria:[11]

1. The field must be under the direct management control of a single rice-producing legal entity.
2. The field area must be contiguous across field 'checks'.
3. Water management (flooding and drainage events) within the field boundary must be relatively homogenous across the field area during a reporting period. There is no set definition for homogeneous water management; however standard practice suggests that most rice fields have a flood-up duration across all field checks of less than 96 hours from start to finish (4 acre-inches per acre or more).[12]

[8] For the purposes of this protocol, non-flooded should be interpreted to mean that there is not standing water (1 inch or more) on the field.
[9] DANR, publication 8425.
[10] More specifically, to effectively quantify field-level emissions using the biogeochemical process model DNDC, the management practices (model inputs) must be homogeneous across the field.
[11] The Reserve believes that in most cases a field defined according to the specified criteria in this protocol will be compatible with a field as defined by the UDSA Farm Service Agency (FSA) Field I.D. protocols.
[12] Note that when recording the date of flood-up for modeling purposes, the date shall be equal to the date when the last field 'check' was flooded to approximately 4 inches or more. This is conservative.

4. Fertilizer management must be relatively homogenous. This criterion is met when application rates across the field do not vary by more than 15 percent of the average application rate for the entire field. During a reporting period, every fertilizer application event must be completed for the entire field on the same day with the same type of fertilizer. A field may have multiple fertilizer application events, as long as each application is homogenous (e.g. consistent rate, timing and type) across the field.
5. Crop residue management within the field boundary must be homogenous across the field area within a reporting period. For example, any burning or baling that occurs on a field must occur across the entire field; there can be no fields that have been partially burnt or baled.
6. The field must have at least five years of rice yield data available for DNDC model calibration.[13]

The above criteria shall be confirmed by the verification body using professional judgment when necessary. If a field does not meet the criteria above, the field shall be divided into sub-fields that meet the field definition criteria, and each sub-field shall be modeled and reported on separately.

2.2.2 Defining the Cultivation Cycle

For the purposes of this protocol, a cultivation cycle is defined as the period starting the day immediately after harvest of one rice crop and ending the last day of the next rice crop harvest the following calendar year. Since this protocol is only applicable to annual rice crops, the cultivation cycle is further defined as approximately 365 days. See Section 5.1 for guidance on how a reporting period is defined and Section 5.3 for guidance on requirements for modeling annual versus cultivation-cycle emissions.

2.3 The Project Developer

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 may also be project aggregators, and can represent one or more projects. Project developers/aggregators must be a legally constituted entity (e.g. a corporation, city, county, state agency, agricultural producer, or a combination thereof). An individual rice grower may serve as a project developer of a single-field project, project aggregator for his/her own fields, or as a project aggregator for a group of fields. Rice growers who elect to enroll in a project aggregate and not serve as a project developer are referred to as “project participants.” Project participants must have authority to make cultivation management decisions on their fields that are enrolled in the project aggregate. Project participants are also required to be a legally constituted entity (e.g. an individual, corporation etc.).

Project developers/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 this protocol. Project developers/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

[13] USDA FSA Abbreviated Farm Records may be a useful resource for documenting historical yields and/or practices on a particular rice field, however these reports are not required to be used. Note that in this protocol yield refers to the weight of the rice before it is milled, so it includes the weight of the husks.

behalf. The scope of project developer/aggregator services is negotiated between the project participants and the project developer/aggregator and should be reflected in contracts between the project participants and the project developer/aggregator.

Project aggregators have the authority to develop their own internal monitoring, reporting, and other participation requirements for individual fields as they deem necessary, as long as these internal requirements do not conflict with any requirements outlined in this protocol.

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 project developer/aggregator must attest to the Reserve that they have exclusive claim to the GHG reductions resulting from all fields in the project. The Project developer/aggregator must attest to this requirement by submitting a signed Attestation of Title form for single-field projects or Aggregator Attestation of Title[14] form for project aggregates, prior to the commencement of verification activities each time the project is verified (see Section 8). In the case of project activities taking place on leased fields (i.e. the project developer/participant is not the land owner, but rather a lessee), the project developer must notify the land owner with a Letter of Notification of the Intent to Implement a GHG Mitigation Project on the respective field. Sufficient evidence must be given to the verifier to demonstrate that such a letter was sent (e.g. evidencing the use of certified mail).

Although 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.

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.

2.4 Project Aggregates

Incorporated into the RCPP is an option for project aggregation that aims to facilitate greater participation by farmers by leveraging economies of scale and technical expertise of aggregators. Through aggregation, technical complexities of the methodology and other potential barriers to adopting practice changes in agriculture may be overcome. Specifically, aggregators can acquire appropriate technical expertise, enabling them to implement and manage projects that fulfill protocol requirements on behalf of farmers. Aggregation allows for “economies of scale” within the methodology, in terms of streamlined requirements for individual farmers, while upholding rigorous standards at the level of the aggregate. This is primarily accomplished through pooling and sampling fields for verification activities. In addition, aggregation can help to increase the accuracy of GHG reduction estimates at a program level by encouraging greater participation, which reduces structural uncertainty within the DNDC model.

[14] The Reserve Aggregator Attestation of Title form is available at http://www.climateactionreserve.org/how/program/documents/.

2.4.1 Field Size Limits and Other Requirements

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.

There is no 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. There are, however, 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. Field size limitations are in place to minimize the influence a single large field may have on a project aggregate's calculations.

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

Number of Fields in Aggregate	Maximum Acreage of a Single Field (% of Aggregate Acreage)
2	70%
3	50%
4	33%
5 or more	25%

2.4.2 Entering an Aggregate

Individual fields may join a project aggregate by being added to the aggregate's Project Submittal Form (if joining at aggregate initiation) or by being added through the New Field Enrollment Form (if joining once the aggregate is underway).

Single-field projects that have already been submitted to the Reserve may choose to join an existing aggregate at any time by submitting a Project Aggregate Transfer Form to the Reserve. The project aggregator will also need to submit a New Field Enrollment Form, listing that field. However, emission reductions for a given field may only be reported to one project in a given cultivation cycle. Thus in the case of a single-field project joining an aggregate during a cultivation cycle, the project developer must chose to either continue to report as an SFP for the remainder of the cultivation cycle or report the entire current cultivation cycle as part of the aggregate.

When a field enters an aggregate, the project aggregator must ensure that all other requirements for each field (as outlined in Sections 2.2, 2.3 and 2.4) continue to be met with all the necessary documentation on file.

2.4.3 Leaving an Aggregate

Fields must meet the requirements in this section in order to leave or change aggregates and continue reporting emission reductions to the Reserve. In all cases, emission reductions must be reported for a complete cultivation cycle, as defined in Section 2.2.2, and no CRTs may be claimed for a field that does not participate and report data for a full cultivation cycle.

Project activities on an individual field may be terminated and the field may elect to leave an aggregate at any time.

Individual fields may elect to leave an aggregate and participate as a single-field project for the duration of their crediting period. To leave an aggregate and become a single-field project, the project participant must open a project developer account on the Reserve and submit a Project

Submittal Form to the Reserve, noting both that it is a transfer project and the aggregate from where it transferred.

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
2. The original aggregate is terminated (e.g. goes out of business)
3. The aggregator breaches its contract with the project participant

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.

2.4.4 Changes in Land Ownership, Management or Tenant Occupancy

A field in an aggregate 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:

- The contract with the project aggregator is transferred from the old to the new project participant
- 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
- Implementation of the approved management practices continues without change until the end of the current reporting period[15]

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 five-year crediting period by fulfilling the three requirements above.

[15] 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	→	*First day of cultivation cycle during which approved activity is implemented*
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 against field measured methane emissions, 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.

3.1.1 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.

3.1.2 High Carbon Content Soils

As the DNDC model has not been validated on soils with SOC content greater than 3 percent, fields that have soil with organic carbon content greater than 3 percent in the top 10 cm of soil are not eligible at this time. The organic carbon content of the field shall be determined by using SSURGO data or soil sampling in accordance with Appendix B, Step 1.4. Where SSURGO data on SOC content is not available to a depth of 10 cm for any given field, that field must use field measurements or data from the STATSGO database to determine eligibility.

3.1.3 Fields Using Nitrification/Urea Inhibitors and Controlled Release Fertilizers

The DNDC model has not been validated for use on fields that have been treated with nitrification inhibitors, urea inhibitors or controlled release fertilizers. Therefore, fields that have used such products in either the five year baseline period or a project year are not eligible under this protocol.

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. A complete cultivation cycle begins with post-harvest residue management and culminates at the end of the rice crop harvest and thus may be slightly greater or less than 365 days depending on planting/harvest dates. More information on how to define a cultivation cycle is found in Section 2.2.2.

Each field has a unique start date, defined as the first day of a cultivation cycle during which one or more of the approved project activities are implemented at the field. Approved project activities initiated prior to the start date (i.e. during the baseline period) are permissible, but must be represented in the field's baseline; as such project activities must go beyond baseline practices in order to generate any additional emission reductions.

To be eligible, a field must submit as a single-field project or join an active or new aggregate before the end of the first cultivation cycle after the start date.[16] 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 of crediting). During the last six months of a field's crediting period, project developers/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 3.5) or is not included in the pool of fields potentially selected for verification, for any number of reasons, still count towards the five-year crediting period. If a project developer wishes to apply for another crediting period, the project must meet the requirements of the most current version of this protocol, including any updates to the Performance Standard Test (Section 3.5.1). The pre-project baseline for the initial crediting period shall be retained for any subsequent crediting periods.[17]

Crediting periods do not apply to project aggregates, but rather only to individual fields within a project aggregate and to single-field projects.

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 prior to the field's start date resulted in anaerobic conditions. This requirement is met by demonstrating all the following criteria are met:

1. Each individual rice field has been under continuous rice cultivation for five cultivation cycles preceding the field's start date, with no more than one fallow season. In instances

[16] Fields are considered submitted when the project developer/aggregator has fully completed and filed with the Reserve the appropriate Submittal Form, or the New Field Enrollment form, available on the Reserve's website.
[17] This is known as a continuation of current practices baseline scenario, and is considered appropriate in the circumstances.

where a fallow season occurred, the field must have been under rice cultivation for five of the six years prior to the start date; and

2. Each individual rice field was flooded for a period of at least 100 days during each of the five rice-growing cultivation cycles preceding the field's start date. Fields that are unable to meet this requirement due to events beyond management control (e.g. drought conditions), can meet this requirement by demonstrating that 100 or more days of flooding is common practice for the field, and that drought conditions or other conditions beyond management control prevented normal flooding practices; and
3. Management records for each individual rice field are available for each of the past five rice-growing cultivation cycles preceding the field's start date. At a minimum, management records must include:
    - Annual rice yields
    - Planting and harvest dates
    - Flooding and draining 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. Although multiple fields are submitted together in the case of a project aggregate, each participating field must separately pass the Performance Standard Test, for each approved project activity that is implemented on the field, in order to be eligible.

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.[18] 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 3.1 below provides the Performance Standard Test for each approved project activity.

[18] 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 with a delayed flood	A rice field passes the Performance Standard Test by implementing a dry seeding technique combined with delayed flooding.	Research indicates that dry seeding is currently practiced on less than 3 percent of the CA rice acreage.[19]
	Post-harvest rice straw removal and baling	A rice field passes the Performance Standard Test by implementing post-harvest rice straw removal and "baling."	Research indicates that residue removal (baling) is currently very limited and variable, occurring on an estimated 2 to 7 percent of the CA rice acreage. Despite initiatives launched by state agencies and private partnerships, the market for rice straw has not grown as expected.[19]

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 in place on the project start date (including, but not limited to, 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 Legal Requirement Test, the field is eligible to earn CRTs from a project activity for the remainder of the five-year crediting period, regardless of changes in legal requirements.

To satisfy the Legal Requirement Test, project developers (including aggregators) must submit a signed Attestation of Voluntary Implementation form[20] prior to the commencement of verification activities for the first verification period. Aggregators must also submit a signed Attestation of Voluntary Implementation form on behalf of new project fields in the aggregate prior to the commencement of verification activities each time new fields join the project aggregate. Individual project participants who are part of a project aggregate are not separately 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 Monitoring Plan (Section 6.2) must include procedures that the aggregator will follow to ascertain and demonstrate that all new fields in the project aggregate pass the Legal Requirement Test at the time of the field's start date.

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.

[19] See Appendix C for a summary of performance standard research.
[20] Form available at http://www.climateactionreserve.org/how/program/documents/.

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.[21]

As of the Effective Date of this protocol, the Reserve did not identify any ecosystem service markets besides the carbon market that issues credits for the project activities included in this protocol.[22] As such, credit stacking does not need to be addressed by this protocol at this time.

The USDA Natural Resources Conservation Service (NRCS) provides payments for ecosystem services through programs like the Environmental Quality Incentives Program and the Conservation Stewardship Program. These are federal programs that are implemented at the state and local level. In California, NRCS Conservation Practice Standard (CPS) 344A – *Residue Management, Seasonal Rice Straw Residue* provides 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,[23] and CPS 329 – *Residue and Tillage Management, No Till/Strip Till/Direct Seed* can provide support for dry seeding.[24]

CPS 344A and CPS 329 have primarily been used in California to fund other management practices besides baling and dry seeding.[25] Because baling and dry seeding are expensive, uncommon, and generally not already funded by NRCS programs, the use of NRCS payments to help finance either project activity under this protocol is allowed, except as specified below.

Stacking NRCS payments for baling under CPS 344A with CRTs for baling under this protocol is not allowed if a NRCS contract for baling on a project field was in place and the baling was completed prior to the project being submitted to the Reserve.

Stacking NRCS payments for dry seeding under CPS 329 with CRTs for dry seeding under this protocol is not allowed if dry seeding was specified in the conservation plan developed with NRCS for a project field and dry seeding was implemented prior to the project being submitted to the Reserve.

Note that if a field receives NRCS payments for any activity *other than* baling or dry seeding, those payments do not affect field eligibility, as the payments were awarded for different activities than those credited by this protocol and thus are not considered "stacked."

Furthermore, other fields owned by the farmer are eligible if they are not under agreement to receive NRCS funding for CPS 344A or CPS 329 activities that include project activities. Fields

[21] 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/.

[22] The Reserve did identify a type of air quality offset that is issued in California under the Connelly-Areias-Chandler Rice Straw Phase-down Act of 1991 (Act); 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 Act and this protocol to be "stacking" credits.

[23] NRCS CPS 344A is available on the NRCS Field Officer Technical Guide website at http://efotg.sc.egov.usda.gov//efotg_locator.aspx. To find the appropriate standard, choose state, county, Section IV: Practice Standards and Specifications, and then the Conservation Practices folder.

[24] NRCS CPS 329 is available on the NRCS Field Officer Technical Guide website at http://efotg.sc.egov.usda.gov//efotg_locator.aspx. To find the appropriate standard, choose state, county, Section IV: Practice Standards and Specifications, and then the Conservation Practices folder.

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

that have received CPS 344A or CPS 329 payments in the past (e.g. prior to the field's start date) but have not received payments for at least one year are also eligible.

Table 3.2. Payment Stacking Scenarios

Scenario		Is Project Eligible?	Is the Project Stacking?
1	Field under CPS 344A or 329 agreement that includes baling or dry seeding and agreement was signed *prior* to the project field's start date or submittal to the Reserve (whichever is earlier)	No	n/a
2	Field under NRCS CPS 344A or 329 agreement for activities that do not include baling or dry seeding	Yes	No
3	Field under NRCS agreement for any other CPS	Yes	No
4	Field under CPS 344A or 329 agreement that includes baling or dry seeding and agreement was signed *after* the project field's start date or submittal to the Reserve (whichever is earlier)	Yes	Yes
5	Field that received CPS 344A or 329 payment for the year prior to the project field's start date	No	n/a
6	Field that received CPS 344A or 329 payment in the past, but has not received payment for more than one year	Yes	No

For informational purposes, any other type of ecosystem service payment or credit received for activities on a project field must be disclosed by the project developer/aggregator to the verification body and the Reserve.

3.6 Regulatory Compliance

As a final eligibility requirement, project developers/aggregators must attest that activities on the project fields (including, but not limited to, project activities) do not cause material violations of applicable laws (e.g. air, water quality, water discharge, nutrient management, safety, labor, endangered species protection, etc.) prior to verification activities commencing each time a project is verified. To satisfy this eligibility requirement, the project developers/aggregators must submit a signed Attestation of Regulatory Compliance form[26] or an Attestation of Regulatory Compliance form on behalf of themselves or all enrolled project participants prior to the commencement of verification activities each time the project is verified. Project developers/aggregators are also required to disclose in writing to the verifier any and all instances of legal violations – material or otherwise – caused by activities on project fields.

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

[26] Attestation of Regulatory Compliance form available at http://www.climateactionreserve.org/how/program/documents/.

Individual project participants who are part of a project aggregate are not required to attest to their status of regulatory compliance to the Reserve. However, the project aggregator is encouraged to have in place routine procedures for assessing field-level compliance. The verifier may request supporting documentation about the project aggregator's procedures or about specific fields and such information shall be made available to the verification body during verification, if requested.

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 percent 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 percent of rice fields were consistently found to have the "significant" level of disease, this requirement was eliminated. Today, rice producers must secure Burn Permits (for up to 25 percent of their rice acreage) in order to burn straw.[27]

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 appropriate local air district. Wherever rice straw burning occurs, the project developer must demonstrate that the amount of burning was within legal limits, if legal limits exist such as in California, and that all necessary permits have been secured.

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 Appendix B, Step 1) 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; although 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 level 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 U.S. Fish and Wildlife Service works with private landowners to develop Habitat Conservation Plans (HCP) and Safe Harbor Agreements (SHA). When in effect on a rice field, an HCP or SHA should be considered a legally binding mandate. Project developers/aggregators shall disclose to the verifier any instances when a field is not in compliance with HCP or SHA requirements.

[27] 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.

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 project.[28]

The GHG Assessment Boundary encompasses all the GHG SSRs that may be significantly affected by project activities, including sources of CH_4 and N_2O emissions from the soil, biological CO_2 emissions and soil carbon sinks, and fossil fuel combustion GHG emissions. For accounting purposes, the SSRs included in the GHG Assessment Boundary are organized according to whether they are predominantly associated with an RC project's "primary effects" (i.e. changes in the RC project's soil dynamics, including the predominant CH_4 source but also N_2O emissions from the soil and biological CO_2 emissions) or its "secondary effects" (i.e. unintended changes in emissions due to on-field practice change or upstream/off-field changes in production)).[29] 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.

Note that primary emissions contain some 'indirect' emissions (e.g. N_2O emissions), while secondary effect emissions contain some modeled soil dynamics (e.g. SOC decreases associated with shifting rice production outside of the project area).

Figure 4.1 below provides a general illustration of the GHG Assessment Boundary, indicating which SSRs are included or excluded from the project boundary.

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

Note that for SSRs 6 and 7, some scenarios may require quantification of the SSRs for the project only.

[28] The definition and assessment of sources, sinks, and reservoirs (SSRs) is consistent with ISO 14064-2 guidance.
[29] 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.

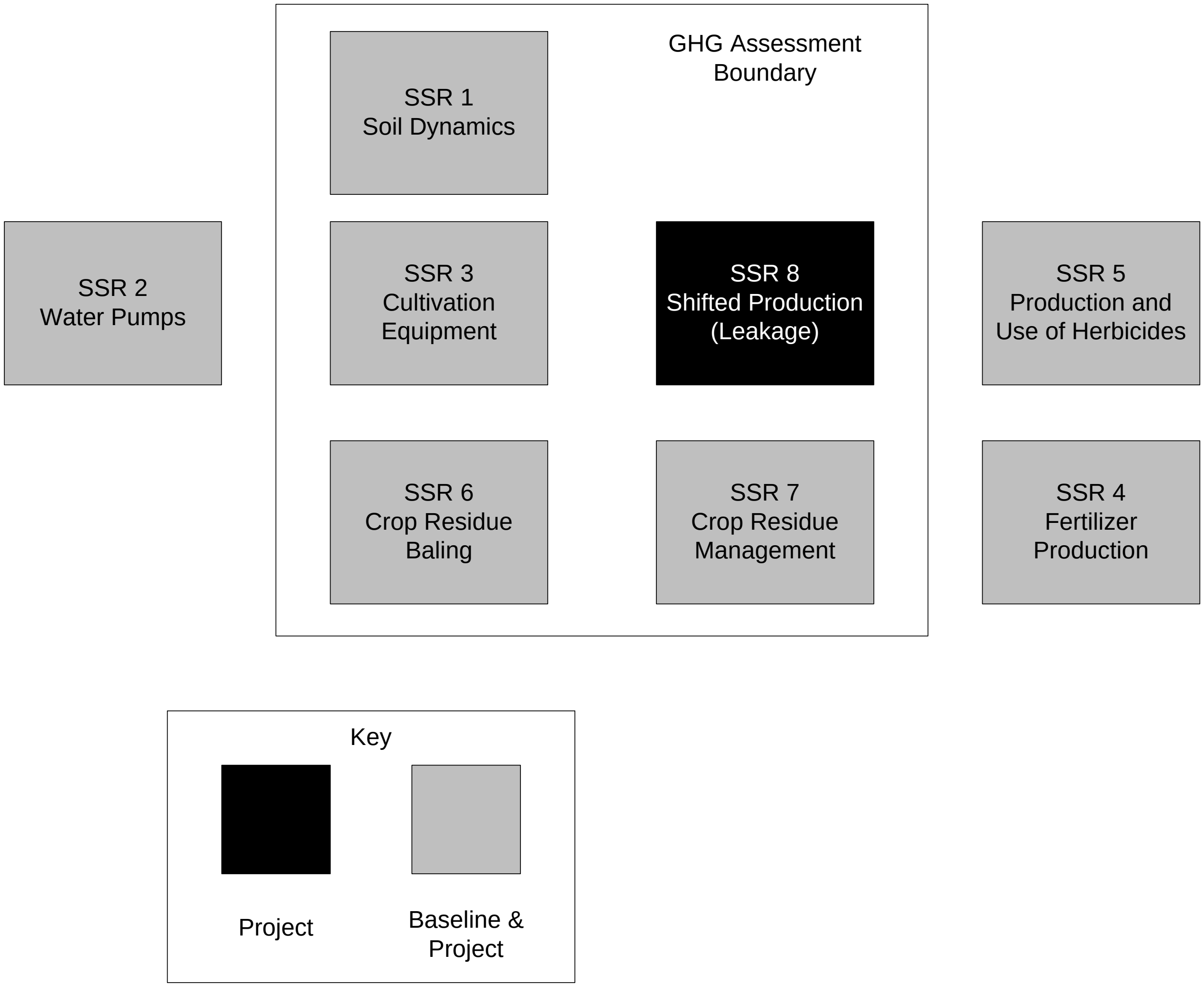

Figure 4.1. General illustration of the GHG Assessment Boundary

Table 4.1. Description of RC Project 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 CO_2 (biogenic), CH_4, N_2O, 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 (if SOC decreased)	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 CH_4 emissions from soil due to reduced flooding and/or reduced organic residues available for decomposition.
		N_2O	I (if increased)	Direct: DNDC Indirect: DNDC and IPCC emission factors	A significant source affected by project activities if fertilizer application amounts and/or dates are changed, or seeding practice is altered. Increases in direct and/or indirect N_2O must be accounted for.
Secondary Effect Sources, Sinks, and Reservoirs					
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 increases from equipment used for field preparation, seeding, fertilizer/pesticide/herbicide application, and harvest	CO_2	I	Emission factors	Emissions 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. GHG Emissions from Fertilizer Production	GHG emissions from synthetic N fertilizer production	CO_2	E	N/A	Excluded, the very small increase in fertilizer demand due to RC projects is unlikely to have an effect on fertilizer production.
		CH_4	E	N/A	Excluded, as this emission source is assumed to be very small
		N_2O	E	N/A	Excluded, the very small increase in fertilizer demand due to RC projects is unlikely to have an effect on fertilizer production.

SSR	Source Description	Gas	Included (I) or Excluded (E)	Quantification Method	Justification/Explanation
5. GHG Emissions from Production and Use of Herbicides	Fossil fuel emissions from Herbicide production	CO_2	E	N/A	Excluded, the very small increase in herbicide demand due to RC projects is unlikely to have an effect on herbicide production.
		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
6. Crop Residue Baling	Fossil fuel emissions from baling and transportation of baled rice straw for offsite use/management	CO_2	I	Baling emission factors	Emissions 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.
7. Crop Residue Management	Fugitive emissions from aerobic or semi-anaerobic rice straw management (onsite or offsite)	CO_2	E	N/A	Emissions from rice straw burning are excluded as they are not considered likely to increase relative to baseline and are biogenic.
		CH_4	I	Emission factors	May be a significant source of fugitive CH_4 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.
8. 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 Quantification Overview

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 an 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 total net GHG emission reductions. GHG emission reductions are calculated for each individual field and summed together over the entire project area. The calculation approach in this section is applicable to single-field projects and aggregates.

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 dissolved 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.

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 Appendix B. In addition to SSR 1, RC projects may result in unintended increases of GHG emissions from secondary effect SSRs. Section 5.5 provides the requirements for calculating those secondary GHG emissions resulting from the project activity that do not rely on use of the DNDC model. Total emission reductions from a field are equal to the combined primary effect 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.

In addition to changes in CH_4, the DNDC model also provides estimates of nitrate leaching, and ammonia and nitric oxide emissions that are used to estimate the changes in indirect N_2O emissions associated with an RC project. The DNDC model also provides estimates of changes in SOC. If emissions of N_2O (both direct and indirect) increase or SOC decrease due to project activity, these emissions must be deducted from the emission reduction estimate. If N_2O (direct or indirect) emissions are reduced or SOC increased due to the project activity, these changes must be excluded from the emission reduction estimate.

5.1 Defining the Reporting Period

Under this protocol, project emission reductions must be quantified per cultivation cycle. The length of time over which GHG emission reductions are quantified is called a “reporting period”. The length of time over which GHG emission reductions are verified is called a “verification period.” For single-field projects, a verification period can cover multiple reporting periods (see Section 7.4.1). For aggregate projects, the verification period is limited to a single reporting period (i.e. a single cultivation cycle).

For single field projects, the reporting period shall be defined using the exact dates corresponding to the beginning and the end of the cultivation cycle for the particular field.

For an aggregate, the individual fields will likely 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 for each individual field. Therefore, the reporting period must be uniformly defined for the aggregate for reporting purposes. For reporting reductions from each cultivation cycle to the Reserve, the aggregate reporting period shall be defined as starting on October 1 and ending on September 30 of the following year. This defined reporting period is for reporting purposes only; the emission reductions reported for the aggregate must include the emission reductions achieved over the complete cultivation cycle for each participating field in the aggregate.[30]

Note that in order to model emissions for any given cultivation cycle, it is necessary to model two full years of data, as each cultivation cycle spans across two calendar years. See Section 5.3 for guidance on how to reconcile modeling annual emissions with modeling emissions for the cultivation cycle.

5.2 Baseline Modeling Inputs

To set the baseline scenario inputs within the DNDC model for each cultivation cycle, the project developer must use field management data from five cultivation cycles prior. Given that two calendar years of data are required for every cultivation cycle being modeled (as set out in Section 5.3 below), inputs for the first baseline cultivation cycle must be derived from records starting in the fall of the fifth year prior to the start date and ending with the following rice harvest in the fall of the fourth year prior to the start date. The last baseline cultivation cycle in the crediting period shall include data from the fall of the year before the project started through to the rice harvest immediately preceding the project start date. In subsequent crediting periods, the baseline scenario will continue to be set using data from the five cultivation cycles immediately prior to the project.

5.3 Deriving Cultivation Cycle Emissions from Calendar-Year Modeling Results

It is important to note that the DNDC model operates on a calendar year, beginning on January 1 and ending on December 31. The model's daily output files use Julian days, where January 1 represents Julian Day 1, January 2 represent Julian Day 2, and December 31 represents Julian Day 365.[31] However, project developers must quantify emissions and emission reductions that occur during the reporting period of a given field, which is defined by the rice crop's cultivation cycle beginning in fall and running through the fall of the following year (e.g. October 1 to September 30). As such, for every instance in this protocol where the project developer is directed to model a cultivation cycle, the project developer must model two full calendar years, so as to capture the last two to three months in the first year, and the first nine to ten months in the following year that make up the relevant cultivation cycle.[32]

For ease of monitoring, reporting, and verification, the Reserve encourages project developers to use Julian Dates in addition to calendar dates wherever possible, but particularly when

[30] All emissions reductions from each field's cultivation cycle must be reported under the corresponding reporting period for the aggregate, even if the dates of the cultivation cycle and reporting period do not completely overlap. For any given field, emissions reductions achieved during a cultivation cycle may only be reported under a single aggregate reporting period.

[31] A Julian Day calendar provided by NASA is available at: http://www-air.larc.nasa.gov/tools/jday.htm.

[32] In determining project emissions, one strategy for economizing on required modeling runs is to conduct modeling only after input data for the entire two calendar years have been collected, i.e. at the end of the second calendar year, rather than at the end of the cultivation cycle. This will generate results for the initial 2-3 months of the subsequent cultivation cycle, avoiding the need to model the entire calendar year again.

reporting the first and last days of a cultivation cycle, as this will ease project accounting and reduce human error associated with model inputs.

5.4 Quantifying GHG Emission Reductions

The emission reductions for a project are calculated by subtracting the total secondary effect emissions (SE) from the total primary emission reductions (PER) (adjusted for uncertainty) for the entire project area. Equation 5.1 below provides the general emission reduction calculation, applicable to all projects.

Equation 5.1. Calculating GHG Emission Reductions

$$\boldsymbol{ER = PER - SE}$$

Where,

			Units
ER	=	Total emission reductions from the project area for the reporting period	tCO_2e
PER	=	Total primary GHG emission reductions from soil dynamics (SSR 1) from each project during the reporting period adjusted for uncertainty (as calculated in Section 5.4.3)	tCO_2e
SE	=	Total secondary effect GHG emissions caused by project activity during the reporting period for each project (as calculated in Section 5.5)	tCO_2e

Table 5.1 below provides an overview of the key steps, calculations and equations necessary to quantify PER and SE emissions for each field and the project as a whole.

Table 5.1. Overview of Quantification Steps

STEP	OVERVIEW	EQUATION
1. Calculate primary emissions for baseline scenario and project scenario for each field	Calculate average cultivation cycle baseline and project scenario GHG values. This involves: ▪ Conducting 2,000 Monte Carlo runs of the DNDC model for both calendar years within which the cultivation cycle falls, for both the baseline and project scenarios (4 years total); ▪ Extracting data from DNDC modeling results corresponding to the cultivation cycle; ▪ Calculating cultivation cycle GHG parameter values for each Monte Carlo run; and ▪ Averaging these values across the 2,000 Monte Carlo runs for both the baseline and project scenarios.	Equation 5.2
2. Calculate primary effect emission reductions for each field (unadjusted for uncertainty)	Preliminary primary effect emission reductions for each field are calculated using results from the baseline and project modeling calculations in Step 1.	Equation 5.3
3. Calculate uncertainty-adjusted primary emission reductions for each field	Apply soil and structural uncertainty deductions to preliminary primary effect emission reductions for each field to calculate final primary effect emission reductions.	Equation 5.4

4. Calculate increased emissions from cultivation equipment	Choose from two alternative approaches to calculate emissions from increased fuel emissions from cultivation equipment.	Equation 5.5 or Equation 5.6
5. Calculate emissions from rice straw end use	Calculate emissions associated with changes in rice straw management, using default emission factors provided in Appendix A.	Equation 5.7
6. Calculate emissions from activity leakage	Calculate emissions associated with any shift in rice production outside of the project boundary, attributed to reductions in project yields.	Equation 5.8 Equation 5.9 Equation 5.10
7. Calculate total secondary effect emissions for the project	Sum together emissions from increased fossil fuel usage, alternative residue management activities, and activity leakage.	Equation 5.11

5.4.1 Step 1: Calculate Primary Emissions for Baseline and Project Scenarios for Each Field

This section provides guidance on how to use results from DNDC Monte Carlo modeling runs to calculate average cultivation cycle emissions for both the baseline and project scenarios for each field. These average cultivation cycle emissions are then input into Equation 5.3 to calculate primary emission reductions for each field. For the purposes of this protocol, the modeling of GHG emissions from soil dynamics under baseline and project scenarios must be performed using Version 9.5 of the DNDC model, which shall be obtained directly from the Reserve.

Detailed guidance is provided in Appendix B on how to undertake the modeling itself, extract relevant results and develop the necessary inputs for Equation 5.2 below. Specifically, Appendix B, Step 1 provides guidance to help project developers understand the necessary DNDC data input parameters; Step 2 instructs project developers on how to prepare input files and what to do in case of missing data; Step 3 instructs project developers on how to properly prepare DNDC for modeling; and Step 4 instructs project developers on how to undertake the modeling of emissions, extract relevant results and develop the values to be input into Equation 5.2 below.

In order to quantify primary emission reductions for each field, project developers shall first calculate annual baseline and project scenario GHG values using data extracted from DNDC modeling results.

For both the baseline and project scenarios, GHG emissions are calculated by performing 2,000 Monte Carlo runs of the DNDC model for each field, for each calendar year being modeled.[33]

For each of the 2000 Monte Carlo runs for a field, the project developer must extract GHG parameter values corresponding to the dates of the field's cultivation cycle (i.e. extracted from the appropriate range within each modeled calendar year). A single cultivation cycle value is then determined for each GHG parameter, by summing daily values (for emissions) or by

[33] As set out in Section 5.3, emissions will need to be modeled separately for four calendar years: the two calendar years that capture the baseline scenario cultivation cycle and the two calendar years that capture the project scenario cultivation cycle.

identifying the value on the last day of the cultivation cycle (soil carbon).These single values are then input into Equation 5.2 to be averaged across the 2,000 Monte Carlo runs in order to generate a single average value for each GHG parameter for the cultivation cycle. Refer to Step 4 in Appendix B for detailed guidance on how to perform these steps. Appendix C also provides more general guidance on how to use the DNDC model, including screen shots, step by step instructions, and advice on performing project feasibility analysis with the model. Further guidance can also be found in the *DNDC User's Guide*, available on the Reserve's RCPP webpage.[34]

The results of Equation 5.2 are a single average value for each of the direct emission parameters (N_2O, CH_4, and SOC content) and indirect emission parameters (NO_3 and NH_3+NO_x) that are used to calculate primary GHG reductions. Once these values are calculated for both the baseline and project scenarios, they are input into Equation 5.3, to calculate the total primary emission reductions for each field.

[34] A copy of the *DNDC User's Guide* can be found on the protocol webpage at http://www.climateactionreserve.org/how/protocols/rice-cultivation/.

Equation 5.2. Calculating GHG Emissions from Monte Carlo Runs for Field i

$$\boldsymbol{N_2O_i = \frac{\sum_{j=1}^{2000}\{(N_2O_{Dir,j,i} + (N_{Leach,j,i} \times 0.0075) + (N_{Vol,j,i} \times 0.01)\}}{2000} \times \frac{44}{28} \times 310}$$

$$\boldsymbol{CH_{4_i} = \frac{\sum_{j=1}^{2000}\left(CH_{4_{j,i}}\right)}{2000} \times \frac{16}{12} \times 21}$$

$$\boldsymbol{SOC_{LDcc,i} = \frac{\sum_{j=1}^{2000}\left(SOC_{LDcc,j,i}\right)}{2000} \times \frac{44}{12}}$$

Where,

			Units
N_2O_i	=	Average cultivation cycle direct and indirect N_2O emissions (for either the baseline or project scenario) from rice field *i*, equal to the average value of all Monte Carlo runs *j*	kg CO_2e/ha
j	=	*1, 2, 3 …2000* Monte Carlo runs	
$N_2O_{Dir,j,i}$	=	Cultivation cycle N_2O emissions from rice field *i* (for either the baseline or project scenario) from Monte Carlo run *j*	kg N_2O-N/ha
$N_{Leach,j,i}$	=	Cultivation cycle nitrate leaching loss from rice field *i* (for either the baseline or project scenario) from Monte Carlo run *j*	kg NO_3-N/ha
$N_{Vol,j,i}$	=	Cultivation cycle ammonia volatilization and nitric oxide emissions from rice field *i* (for either the baseline or project scenario)from Monte Carlo run *j*	kg NH_3-N + kg NO_x-N /ha volatized
44/28	=	Unit conversion from kg N_2O-N to kg N_2O	
310	=	Global warming potential of N_2O	
$CH_{4\ i}$	=	Average cultivation cycle CH_4 emissions (for either the baseline or project scenario)from rice field *i*, equal to the average value of all Monte Carlo runs *j*	kg CO_2e/ha
$CH_{4\ j,i}$	=	Cultivation cycle CH_4 emissions from rice field *i* (for either the baseline or project scenario) from Monte Carlo run *j*	kg CH_4-C/ha
16/12	=	Unit conversion of C to CH_4	
21	=	Global warming potential of CH_4	
$SOC_{LDcc,i}$	=	Average cultivation cycle final SOC, equal to the average value of all Monte Carlo runs *j,* of the soil organic carbon content of rice field *i* on the last day of the cultivation cycle (for either the baseline or project scenario)	kg CO_2e/ha
$SOC_{LDcc,j,i}$	=	SOC content of rice field *i* on the last day of the cultivation cycle (for either the baseline or project scenario) from Monte Carlo run *j*	kg SOC-C/ha
44/12	=	Unit conversion of C to CO_2	
0.0075	=	Emission factor for N_2O emissions from N leaching and runoff[35]	kg N_2O-N / kg NO_3-N
0.01	=	Emission factor for N_2O emissions from atmospheric deposition of N on soils and water surfaces and subsequent volatization[36]	kg N_2O-N / (kg NH_3-N + kg NO_x-N)

[35] IPCC Guidelines for National GHG Inventories (2006), Vol.4, Ch.11, Table 11.3.
[36] Ibid.

5.4.2 Step 2: Calculate Primary Emission Reductions for Each Field (Unadjusted for Uncertainty)

In order to calculate the total PER for each field (PER_i) (unadjusted for uncertainty), project developers must compare the baseline and project scenario results calculated in Step 1 for the key GHG parameters CH_4, N_2O, and SOC. Any decreases in N_2O or increases in SOC are excluded from the total PER_i results, as the protocol does not credit projects for such changes.

The calculations necessary to quantify PER_i are set out in Equation 5.3 below.

Equation 5.3. Total Primary Effect GHG Emission Reductions for each Field (Unadjusted for Uncertainty)

$$PER_i = \frac{\left\{(N_2O_{B,i} - N_2O_{P,i}) + (CH_{4_{B,i}} - CH_{4_{P,i}}) - (SOC_{LDBcc,i} - SOC_{LDPcc,i})\right\}}{1000} \times Area_i$$

Where, Units

PER_i	=	Primary effect GHG emission reductions for field *i* ***** (unadjusted for uncertainty)	tCO_2e
$N_2O_{B,i}$	=	Average baseline cultivation cycle N_2O emissions for field *i*	kg CO_2e/ha
$N_2O_{P,i}$	=	Average project cultivation cycle N_2O emissions for field *i*	kg CO_2e/ha
$CH_{4\ B,i}$	=	Average baseline cultivation cycle CH_4 emissions for field *i*	kg CO_2e/ha
$CH_{4\ P,i}$	=	Average project cultivation cycle CH_4 emissions for field *i*	kg CO_2e/ha
$SOC_{LDBcc,i}$	=	Average SOC value on the last day of the baseline cultivation cycle for field *i*	kg CO_2e/ha
$SOC_{LDPcc,i}$	=	Average SOC value on the last day of the project cultivation cycle for field *i*	kg CO_2e/ha
$Area_i$	=	Area of field *i* in hectares	ha

***** In order to ensure that only reductions in CH_4 are credited on each field, the term ($N_2O_{B,i} - N_2O_{P,i}$), must be set equal to zero if it is > 0; and the term ($SOC_{LDBcc,i} - SOC_{LDPcc,i}$) must be set equal to zero if it is < 0.

5.4.3 Step 3: Calculate Uncertainty-Adjusted Primary Emission Reductions for each Field

When calculating PER, this protocol requires project developers to account for two types of uncertainty: model structural uncertainty and soil input uncertainty. 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, and roughly quantifies how well the model represents reality. Because physical and chemical properties of soil have a significant impact on CH_4 and N_2O production, consumption, and emissions, further variability and uncertainty is also introduced to the model in the sampling of soil data and the subsequent modeling of GHG emissions using such data. This is known as soil input uncertainty.

The protocol requires that project developers account for both types of uncertainty by applying the appropriate uncertainty deductions to the modeled primary emission reductions. The soil input uncertainty deduction must be calculated by project developers for each field based on results from DNDC to model baseline and project scenario emissions for that field. The model structural uncertainty deduction is provided by the Reserve. Further guidance on each type of uncertainty deduction is provided below.

5.4.3.1 Model Structural Uncertainty Deduction

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). Project developers do not need to calculate the model structural uncertainty deduction, but instead obtain the appropriate structural uncertainty deduction from the Reserve at the time of verification.

Appendix C provides the structural uncertainty derivation procedure developed to adjust DNDC results for model structural uncertainty. To ensure conservativeness in estimates of project emission reductions, all projects must use the adjustments provided by the Reserve to account for structural uncertainty for Version 9.5 of the DNDC model, as specified in Equation 5.4.

Because there is ongoing 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 the table of structural uncertainty factors will be updated. Further, the factors decline as more fields implement rice cultivation projects. As such, the most up-to-date factors will be available on the Reserve website. Project developers must use the structural uncertainty deduction factor (μ_{struct}) for the appropriate reporting year that is published on the Reserve website at the time of verification.

5.4.3.2 Soil Input Uncertainty Deduction

Project developers must calculate an appropriate soil input uncertainty deduction using results from the same Monte Carlo analyses performed to model baseline and project emissions for each field. Detailed guidance on conducting Monte Carlo analyses and developing soil input uncertainty deductions is provided in Appendix B, Step 4 and Step 5 respectively.

5.4.3.3 Applying Uncertainty Deductions to Primary Emission Reductions

Once an appropriate soil input uncertainty deduction has been calculated, in accordance with Appendix B, Step 5.1, and an appropriate structural uncertainty deduction has been obtained from the Reserve, both deductions are applied to PER_i in order to calculate uncertainty adjusted total PER for each field. The application of the uncertainty deductions to PER_i is shown in Equation 5.4 below.

Equation 5.4. Applying Uncertainty Deductions to Primary Emission Reductions

$$\boldsymbol{PERud} = \sum_{i=1}^{m} \{(\mu_{\boldsymbol{inputs_i}} \times \boldsymbol{PER_i}) - \mu_{\boldsymbol{struct}}\}$$

Where,

			Units
PERud	=	Primary GHG emission reductions over the entire project area, accounting for uncertainty deductions	tCO_2e
m	=	Number of individual rice fields included in the project area	
$\mu_{inputs,i}$	=	Accuracy deduction factor for the cultivation cycle for individual rice field *i* due to soil input uncertainties, refer to Appendix B, Step 5.1	fraction
PER_i	=	Primary GHG emission reductions for field *i* (from Equation 5.3)	tCO_2e
μ_{struct}	=	Accuracy deduction from model structural uncertainty for the reporting period, values available on Reserve website	

5.5 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.

The total secondary effect GHG emissions are equal to:

- Increased CO_2 emissions from mobile combustion of fossil fuels by farm equipment used for field preparation, seeding, and cultivation (SSR 3, Step 4), plus
- CO_2 emissions from transport and processing of rice straw residues (SSR 6, Step 5), and methane emissions from aerobic or semi-anaerobic treatment/use of baled rice straw residue (SSR 7, Step 5), plus
- Emissions of CH_4 and CO_2 due to shifted rice production outside the project boundary (SSR 8, Step 6)

5.5.1 Step 4: Calculate Project Emissions from Onsite Fossil Fuel Combustion

Included in the GHG Assessment Boundary are secondary CO_2 emissions resulting from increased fossil fuel combustion for onsite equipment used for performing RC management activities related to seeding, fertilizer application, and herbicide application. Fossil fuel emissions from baling rice straw are incorporated into the emission calculation in Section 5.5.2 below and are not to be included when quantifying increased fossil fuel emissions per this section. Secondary emissions from cultivation equipment need not be quantified if there is no change in the type or hours of cultivation equipment usage due to implementation of the project (e.g. no new equipment used for dry seeding). But 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 using either Equation 5.5 or Equation 5.6 below.

Two approaches are provided to calculate secondary emissions from cultivation equipment. Approach 1 calculates emissions based on the time needed for each rice cultivation related field operation, the horsepower required for this field operation, and a default emission factor for GHG emissions per horsepower-hours. Approach 2 calculates emissions based on the change in fuel consumption for field operations related to rice cultivation and a default emission factor for GHG emissions per unit of fuel consumed.

Approach 1 is designed to require minimal documentation. The project participant must provide manufacturer's specifications on the horsepower requirements for the new cultivation equipment used, and the time needed per hectare for implementation of the project-specific activity. The time needed to implement the activity should be reported based on work-hour records. However, lacking those records, they may be derived based on the average operation or ground speed of the equipment and the application width per pass (e.g. width of boom). Using Approach 1, project emissions from cultivation equipment are calculated using Equation 5.5.

Equation 5.5. Project Emissions from Cultivation Equipment (Approach 1)

$$SE_{FF,f} = \left(\sum_i \left(EF_{HP-hr,P,i,f} \times HP_{P,i,f} \times t_{P,i,f}\right) - \sum_k \left(EF_{HP-hr,B,k,f} \times HP_{B,k,f} \times t_{B,k,f}\right)\right) \times 10^{-6}$$

If $SE_{FF,f}$ < 0, set $SE_{FF,f}$ to 0

Where,

			Units
$SE_{FF,f}$	=	Increase in secondary emissions from a change in cultivation equipment on field *f*	Mg CO_2e/ha
$EF_{HP\text{-}hr,P,i,f}$	=	Emission factor for project operation *i* on field *f*. Default value is 1311 for gasoline-fueled operations and 904 for diesel-fueled operations[37]	g CO_2e/HP-hr
$HP_{P,i,f}$	=	Horsepower requirement for project operation *i* on field *f*	HP
$t_{P,i,f}$	=	Time required to perform project operation *i* on field *f*	hr/field
$EF_{HP\text{-}hr,B,k,f}$	=	Default emission factor for baseline operation *k* on field *f* Default value is 1311 for gasoline-fueled operations and 904 for diesel-fueled operations[38]	g CO_2e/HP-hr
$HP_{B,k,f}$	=	Horsepower requirement for baseline operation *k* on field *f*	HP
$t_{B,k,f}$	=	Time required to perform baseline operation *k* on field *f*	hr/field
10^{-6}	=	Converting g CO_2e to Mg CO_2e	

Optional Method (determination of *t*)
If time records are not available, use the method below in both baseline and project estimates.

$$t = \frac{10000}{(width \times speed \times 1000)} \times A_f$$

Where,

			Units
t	=	Time requirement for field operation	hr
10000	=	Area unit conversion	m^2/ha
width	=	Application width covered by equipment	m
speed	=	Average ground speed of the operation equipment	km/hr
1000	=	Length unit conversion	m/km
A_f	=	Size of field *f*	ha

Alternately, project participants may choose to quantify secondary emissions from changes in the use of cultivation equipment based on their fuel consumption records (see Equation 5.6, Approach 2, below). If insufficient fuel consumption records are available, Approach 1 must be used.

[37] California Air Resources Board, OFFROAD2007. Available at http://www.arb.ca.gov/msei/offroad/offroad.htm.
[38] Ibid.

Equation 5.6. Increased Emissions from Cultivation Equipment (Approach 2)

$$\boldsymbol{SE_{FF,f}} = \frac{\sum_i \left[(\boldsymbol{FF_{RP,j}} \times \boldsymbol{EF_{FF,j}} \right]}{\mathbf{1000}}$$

If $\boldsymbol{SE_{FF,f}} < 0$, set $\boldsymbol{SE_{FF,f}}$ to 0

Where,			Units
$SE_{FF,f}$	=	Increase in secondary emissions from a change in cultivation equipment on field *f*	Mg CO_2e/ha
$FF_{RP,j}$	=	Total change in fossil fuel consumption for field *f* during the reporting period, by fuel type *j*	gallons
$EF_{FF,j}$	=	Fuel-specific emission factor. Default values are 17.4 for gasoline and 13.7 for diesel[39]	kg CO_2/gallon fossil fuel
1000	=	Kilograms per megagram	kg CO_2/Mg CO_2

5.5.2 Step 5: Calculate 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:[40]

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

- **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 very likely outweigh emissions from transporting rice straw.

[39] California Air Resources Board, OFFROAD2007. Available at http://www.arb.ca.gov/msei/offroad/offroad.htm.
[40] End-uses and descriptions referenced from ANR, 2010.

- **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 like wheat or barley straw. When used for erosion control, rice straw will decompose aerobically because it is spread out on top soil, ensuring an oxygen rich environment during decomposition.

- **Other uses:** Rice straw may be used in small quantities for other uses, such as animal bedding, 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 5.7 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 field rice straw, a conservative default factor can be used in place of an end-use specific default factor. If electing to use end-use specific factors, the project developer must collect and retain straw sales documentation to demonstrate rice straw end-use(s). See Section 6.4.3 for detailed baling monitoring requirements.

Projects must use the emission factor 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 unused rice straw must be used to quantify the emissions from this source.

Equation 5.7. Emissions from Rice Straw End-Use

$$\boldsymbol{SE_{RM,i}} = (\boldsymbol{W_{RS,i}} \times \boldsymbol{EF_{SRB}}) + \sum_{\boldsymbol{U}} [\boldsymbol{W_{RS,U}} \times \boldsymbol{EF_U}]$$

Where,

			Units
$SE_{RM,i}$	=	Total secondary effect GHG emissions from alternative residue management for field *i*	tCO_2e
$W_{RS,i}$	=	Total weight of rice straw in dry tonnes that is swathed, raked, and baled on the field *i*	dry tonne
EF_{SRB}	=	Emission factor for increased fossil fuel emissions from swathing, raking, and baling. The emission factor shall be equal to 0.01 for all fields[41]	tCO_2e / dry tonne
$W_{RS,U}$	=	Weight of rice straw in dry tonnes with end-use *U*. The sum weight of rice straw for all end-uses must equal the total weight of rice straw baled on the field	dry tonne
EF_U	=	Emission factor from Table A.1 in Appendix A for end-use *U*	tCO_2e / dry tonne

[41] 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 emission factor of 8.78 kg CO_2 per gallon of diesel, and assuming 3 tonnes of rice straw per acre, the emissions increase from swathing, raking, and baling is estimated to be 5.85 kg CO_2 per tonne of rice straw.

5.5.3 Step 6: Calculate GHG Emissions from the Shift of Rice Production Outside of Project Boundaries (Leakage)

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,[42] 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.

If a simple summation of project yield, or in the case of aggregate, the aggregate project area yields, shows that yields did not decrease compared to the average historic rice yield for the same area, then this protocol assumes leakage has not occurred and subsequently emissions associated with shifting production do not need to be estimated (i.e. the remainder of this section can be skipped).

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 yield from the project area 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.[43]

The following procedure must be followed for each cultivation cycle to ensure that the yields from the project area have not declined due to project activity. The following procedure is applicable for a single field project. All project aggregates must apply the following procedure to the entire project area, defined as the sum of individual fields included in verification activities:

1. For the five rice cultivation years *t* prior to implementation of the project, normalize the rice yield of the field by the county average for that year, $\boldsymbol{y\_norm_t}$. If the project is an aggregate, calculate $\boldsymbol{y\_norm_t}$ for each of the historical years as the weighted average (by percent of field area) of all fields in the aggregate following Equation 5.8. The distribution of $\boldsymbol{y\_norm_t}$ will have five data points. If a fallow year is present in the baseline period, ignore that year for the purpose of calculating leakage for that particular field. As an additional year of historic yield should have been reported, the field with a fallow year should still have five data points.

[42] McDonald et al. (2002), Russo et al. (2008).
[43] Available at http://quickstats.nass.usda.gov.

Equation 5.8. Normalized Yield for Each Year *t*

For single-field projects: $y\_norm_t = \frac{Y_{f,t}}{Y_{county,t}}$

For aggregate projects: $y\_norm_t = \sum_f \left(A_f \times \frac{Y_{f,t}}{Y_{county,t}} \right) / \sum_f A_f$

Where,

			Units
y_norm_t	=	Normalized yield for each year *t*	fraction
$Y_{f,t}$	=	Yield of field *f* in year *t*	Mg/ha
$Y_{county,t}$	=	County average yield in year *t*	Mg/ha
A_f	=	Size of field *f*	ha

If aggregates span multiple counties, $Y_{county,t}$ must correspond with the county in which field *f* is located.

2. Take the standard deviation, ***s***, and mean of the y_norm_t distribution:

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

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

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

$$y_{min} = \overline{y_{norm_t}} - 2.132 \times s$$

Where 2.132 is the t-distribution value with 95 percent confidence for a one-tailed test with four degrees of freedom (i.e. n is 5),[44] and ***s*** is the standard deviation of the y_norm_t distribution, as calculated in Step 2.

4. For the present cultivation cycle, normalize the yield of each field by the county average for the growing season for the year, and, if the project is an aggregate, calculate the weighted average for all fields in the aggregate to get y_norm_{t0} using Equation 5.8 above and replacing ***t*** with t_0, i.e. the year of the present reporting period.

5. For every year of the crediting period, calculate y_norm_{t0} and compare this value to ***y_min***. If y_norm_{t0} 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 5.9 below. Alternatively, if y_norm_{t0} is larger than ***y_min*** then no emissions associated with shifts in production are assumed to occur and therefore do not need to be calculated.

[44] The t-distribution value of 2.132 = t(0.05, n – 1), where n is 5, and n-1 degrees of freedom is 4. There should always be five data points when performing this calculation in the RCPP as there shall always be 5 years of rice yield data for a given field.

Equation 5.9. GHG Emissions Outside the Project Boundary

$$SE_{PS} = \left(1 - \frac{y\_norm_{t_0}}{y\_min}\right) \times \frac{\sum_i \left(N_2O_{B,i} + CH_{4_{B,i}} - \Delta SOC_{B,i}\right)}{1000}$$

Where,

			Units
SE_{PS}	=	Total secondary effect GHG emissions for the project aggregate from production shifting outside of the project boundary	tCO_2e
y_norm_{t0}	=	Sum of yields for the current cultivation cycle normalized to the county averages	fraction
y_min	=	Minimum yield threshold below which normalized yields are significantly smaller than the historical average	fraction
$N_2O_{B,i}$	=	Baseline cultivation cycle direct and indirect N_2O emissions from rice field *i*, equal to the average of the values of all Monte Carlo runs *j*	kg CO_2e/ha
$CH_{4\ B,i}$	=	Baseline cultivation cycle CH_4 emissions from rice field *i*, equal to the average of the values for all Monte Carlo runs *j*	kg CO_2e/ha
$\Delta SOC_{B,i}$	=	Change in SOC content of rice field *i* during the baseline cultivation cycle, as calculated in Equation 5.10 below	kg CO_2e/ha
1000	=	kg per tonne	kg CO_2/tCO_2

Note: Guidance on how to calculate $N_2O_{B,I,}$ and $CH_{4\ B,I}$ values is provided in Appendix B, Step 4.2, and guidance on how to calculate the $\Delta SOC_{B,I}$ value is provided below.

5.5.3.1 Accounting for Change in Soil Organic Carbon

Unlike N_2O and CH_4 emissions, the baseline SOC value cannot be used as an input in Equation 5.9 as it does not itself represent emissions. Rather, the change in SOC over a given baseline cultivation cycle ($\Delta SOC_{B,i}$) must be calculated using Equation 5.10 below.

In order to calculate $\Delta SOC_{B,i}$, the project developer must calculate the change in SOC that occurred over the relevant baseline cultivation cycle. The project developer must extract the SOC value corresponding to the first Julian day of the baseline cultivation cycle from the first baseline year being modeled and the last Julian day of the baseline cultivation cycle from the second baseline year being modeled.[45] Per Equation 5.10, the project developer must then subtract the SOC value on the first day of the cultivation cycle from the SOC value on the last day of the cultivation cycle. The results must then be converted into CO_2e. This process must be repeated for the 2,000 Monte Carlo runs, and then averaged to determine the appropriate $\Delta SOC_{B,i}$ value to be used in Equation 5.9.

[45] See Section 5.3 for detailed guidance on using two calendar years of modeling for a single cultivation cycle.

Equation 5.10. Change in Soil Organic Carbon in the Baseline Cultivation Cycle

$$\Delta SOC_{B,i} = \frac{\sum_{j=1}^{2000} SOC_{LDBcc} - SOC_{FDBcc}}{2000} \times \frac{44}{12}$$

Where, Units

$\Delta SOC_{B,i}$	=	Change in SOC content of rice field *i* during the baseline cultivation cycle	kg CO_2e/ha
SOC_{LDBcc}	=	SOC stock value on the last day of the baseline cultivation cycle (i.e. the day harvest is complete)	kg C/ha
SOC_{FDBcc}	=	SOC stock value on the first day of the baseline cultivation cycle (i.e. the day after the previous year's harvest is complete)	kg C/ha
44/12	=	Unit conversion of C to CO_2e	

5.5.4 Step 7: Calculate Total Secondary Emissions from Project Activity

Once all of the sources of relevant secondary emissions have been accounted for, the project developer shall calculate total secondary emissions using Equation 5.11 below. The total secondary effect emissions calculated in Equation 5.11 are then input into Equation 5.1 (in Section 5.4) to calculate the total emission reductions for the project.

Equation 5.11. Total Secondary Effect Emissions from Project Activity

$$SE = \sum_{i} (SE_{FF,i} + SE_{RM,i}) + SE_{PS}$$

Where, Units

SE	=	Total secondary effect emissions	tCO_2e
$SE_{FF,i}$	=	Total secondary effect GHG emissions from increased fossil fuel combustion for field *i*, as calculated in Section 5.5.1 (Step 4)	tCO_2e
$SE_{RM,i}$	=	Total secondary effect GHG emissions from alternative residue management for field *i*, as calculated in Section 5.5.2 (Step 5)	tCO_2e
SE_{PS}	=	Total secondary effect GHG emissions for each project from production shifting outside of the project boundary, as calculated in Section 5.5.3 (Step 6)	tCO_2e

6 Project Monitoring

The Reserve requires that Monitoring Plans and Reports be established for all monitoring and reporting activities associated with the project. Under this protocol, two distinct types of Monitoring Plans and Reports must be developed: aggregate level and field level.

A field serial number must appear in the file name of all monitoring records for each distinct field and kept in accordance with this protocol (see Section 7.1.1 for details on how to create field serial numbers).

6.1 Single-Field Monitoring Plan

The Single-Field Monitoring Plan (SFMP) will serve as the basis for verification bodies to confirm that the monitoring and reporting requirements in this section and Section 7 are met for single-field projects, and that consistent, rigorous monitoring and record keeping is ongoing at the project field. The SFMP must be developed and maintained by the project developer. The SFMP must outline procedures on how all of the data included in the Single-Field Report, particularly the parameters in Table 6.1 and Table 6.2, will be collected, recorded, and managed, as specified below and in Section 7.2.1 (see Section 7.3.1 for minimum record keeping requirements). It is the responsibility of the project developer to ensure that the SFMP meets all requirements specified and is kept on file and up-to-date for verification.

The SFMP will outline the following procedures:

- How the GIS shape file and/or KML file will be created
- How the crediting period, verification schedule, and quantification results will be tracked for each field included in the project aggregate
- How to ensure that the project developer holds title to the GHG emission reductions as required in Section 2.3
- Procedures that the project developer will follow to ascertain and demonstrate that the project field at all times passes the Legal Requirement Test and Regulatory Compliance (Section 3.5.2 and 3.6 respectively)
- A plan for detailed record keeping and maintenance that meet the requirements for minimum record keeping in Section 7.3.1
- The frequency of data acquisition
- The frequency of sampling activities
- The role of individuals performing each specific activity, particularly monitoring and sampling
- QA/QC provisions to ensure that data acquisition is carried out consistently and with precision

6.2 Aggregate Monitoring Plan

The Aggregate Monitoring Plan (AMP) will serve as the basis for verifiers to confirm that the project aggregate tracking requirements have been and will continue to be met for each reporting period. The AMP must be developed and maintained by the aggregator. The AMP must outline procedures on how all of the data included in the Aggregate Report will be collected and managed, as specified below and in Section 7.2.2 (see Section 7.3.2 for minimum record keeping requirements).

The AMP will outline the following procedures:

- How the GIS shape file and/or KML file will be created for each field
- How the crediting period, verification schedule, and quantification results will be tracked for each field included in the project aggregate
- How to ensure 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
- 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 Regulatory Compliance (Section 3.5.2 and 3.6 respectively)
- A plan for detailed record keeping and maintenance that meet the requirements for minimum record keeping in Section 7.3.2
- The role of individuals performing each specific activity
- QA/QC provisions to ensure that data collected from the field level, according to data acquisition requirements outlined in the Field Monitoring Plan (FMP) described below, is carried out consistently and with precision at the aggregate level

6.3 Field Monitoring Plan for Project Participants in an Aggregate

The Field Monitoring Plan (FMP) will serve as the basis for verifiers to confirm that the monitoring and reporting requirements in Sections 6 and 7 are met at each field in a 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 and Table 6.2 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
- The frequency of sampling activities
- The role of individuals performing each specific monitoring and sampling activity
- A record keeping plan (see Section 7.3.2.2 for minimum record keeping requirements)
- QA/QC provisions to ensure that data acquisition is carried out consistently and with precision

6.4 Field Data

All fields, whether enrolled in a project aggregate or participating as a single-field project, must monitor the necessary DNDC input data and field management data as specified below. All field-level data and information specified in Sections 6.4.1, 6.4.2, 6.4.3, and 6.4.4 must be collected and retained for verification purposes.

6.4.1 General Field Tracking Data

- Either a GIS shape file or a KML file clearly defining the field boundary (or boundaries), as defined in Section 2.2.1, of each distinct field that is part of the project (Note: project developers may wish to provide verifiers with additional GIS shape files with underlying information about how fields were stratified, e.g. further delineate where management activities are homogenous, how field boundaries map to legal parcels, etc.).
- The coordinates of the most north-westerly point of the field, reported in degrees to four decimal places[46] (to be used for creating field serial numbers)
- The serial number of the field, constructed as specified in Section 7.1.1
- The start date of the field
- Disclosure of any material and immaterial regulatory violations, with copies of all Notices of Violations (NOVs) included in the report
- A list of the project activities implemented on the field during the cultivation cycle
- Field rice yield during the relevant project cultivation cycle and all five baseline cultivation cycles

6.4.2 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 (used in both the baseline scenario cultivation cycle and the project scenario cultivation cycle, and application dates[47]
- Flooding[48] and drainage[49] dates (during the growing season and during post-harvest period)
- Begin and end date of harvesting on the field
- Post-harvesting residue management (e.g. burning, incorporation or baling) description and dates
- Amount of herbicides applied for the baseline scenario cultivation cycle and the project scenario cultivation cycle[50]
- All DNDC input files and output files in *.csv file format
- A summary of all data inputs where permissible deviations from using DNDC or default parameters sourced from UC Davis[51] has occurred (i.e. using field data in place of DNDC defaults for calibration purposes), a justification for any such deviation and appropriate supporting evidentiary material

[46] Longitude reported in degrees to four decimal places provides a spatial resolution of about 11 meters, the resolution of the latitude is slightly less than that.
[47] Amounts of fertilizer used in the baseline scenario cultivation cycle do not need to be verified.
[48] For each field, the flood date shall be equal to the date that the first 'check' began filling.
[49] For each field, the drainage date shall be equal to the date that the last 'check' began draining.
[50] Amounts of herbicide used in the baseline scenario cultivation cycle do not need to be verified.
[51] This information can be sourced directly from UC Davis. See http://ucanr.edu/sites/UCRiceProject/.

6.4.3 Project Activity Data and Documentation

To corroborate field management assertions, each field must collect and 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
    - Quantity of rice straw removed
    - Quantity of rice straw left unused in piles at or near the field
    - List of equipment used
    - Height of the cutting bar used
    - Name of third-party baling service provider (if applicable)
- End-use of rice straw (if using an end-use specific emission factor). All sales contracts or receipts for the rice straw must be retained for verification purposes

6.4.4 Field Monitoring Parameters

Prescribed monitoring parameters, including those specific to DNDC as well as additional parameters necessary to calculate baseline and project emissions, are provided below in Table 6.1 and Table 6.2, respectively. Field monitoring parameters and DNDC input parameters must be determined according to the data source and frequency specified in the tables. Note that verifiers will also need to verify that defaults provided by DNDC for additional parameters not listed in the tables have not been altered. Further guidance on all of the DNDC input parameters can be found in Appendix B, Step 1.1.

Table 6.1. DNDC Model Input Parameters

Parameter	Description	Data Unit	Calculated (c) Measured (m) Reference(r) Operating Records (o)	Measurement Frequency	Comment
Climate	GPS location of field	° decimal to four places	m	Once per project	
	Atmospheric background NH_3 concentration	μg N/m^3	r	Once per crediting period	Source: National Atmospheric Deposition Program data or data from UC Davis.
	Atmospheric background CO_2 concentration	ppm	r	Once per crediting period	Source: National Atmospheric Deposition Program data or data from UC Davis.
	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	Once per crediting period	Source: National Atmospheric Deposition Program data or data from UC Davis.
Soils**	Land-use type	type	m	Once per project	
	Clay content	0-1	m/r	Annual	Source: Measured or SSURGO
	Bulk density	g/cm^3	m/r	Annual	Source: Measured or SSURGO
	Soil pH	value	m/r	Annual	Source: Measured or SSURGO
	SOC at surface soil	kg C/kg	m/r	Annual	Source: Measured or SSURGO
	Soil texture	type	m/r	Annual	Source: Measured or SSURGO
Crop	Planting date	date	m	Annual	Famer records
	Harvest date	date	m	Annual	Famer records
	C/N ratio of the grain	ratio	m/r	Once per variety	Can use default *.dnd file values or defaults derived from UC Davis Jenkins Lab
	C/N ratio of the leaf + stem tissue	ratio	m/r	Once per variety	Can use default *.dnd file values or defaults derived from UC Davis Jenkins Lab
	C/N ratio of the root tissue	ratio	m/r	Once per variety	Can use default *.dnd file values or defaults derived from UC Davis Jenkins Lab
	Fraction of leaves + stem left in field after harvest	0-1	m	Annual	Farmer records
	Maximum yield	kg dry	m	Annual	Farmer records

Parameter	Description	Data Unit	Calculated (c) Measured (m) Reference(r) Operating Records (o)	Measurement Frequency	Comment
		matter/ha			
	Number of tillage events	number	o	Annual	Farmer records
	Date of tillage events	date	o	Annual	Farmer records
	Depth of tillage events	cm (select from 7 default depths) †	o	Annual	Farmer records
Tillage	Number of fertilizer applications	number	o	Annual	Farmer records
	Date of each fertilizer application	date	o	Annual	Farmer records
	Application method	surface / injection	o	Annual	Farmer records
Fertilization	Type of fertilizer	type*	o	Annual	Farmer records
	Fertilizer application rate	kg N/ha	o	Annual	Farmer records (field average if using variable rate applications)
	Number of organic applications per year	number	o	Annual	Farmer records
	Date of application	date	o	Annual	Farmer records
	Type of organic amendment	type	o	Annual	Farmer records
Manure amendment[52] (if used)	Application rate	kg C/ha	o	Annual	Farmer records
	Amendment C/N ratio	ratio	o	Annual	DNDC defaults or Farmer records
	Number of irrigation events	number	o	Annual	Farmer records
	Date of irrigation events		o	Annual	Farmer records
	Irrigation type	Must use the 'flood' default type	o	Annual	Farmer records
Irrigation	Irrigation application rate	mm	o	Annual	Farmer records
	Date of flood-up for growing season	date	o	Annual	Farmer records
	Date of drain for crop harvest	date	o	Annual	Farmer records
	Date of flood-up for winter flooding (if applicable)	date	o	Annual	Farmer records

[52] DNDC allows for data on any soil amendment to be input into the model, and provides default parameters (i.e. C/N ratio) for several types of soil amendments. See Appendix B Step 1.4 for further guidance.

Parameter	Description	Data Unit	Calculated (c) Measured (m) Reference(r) Operating Records (o)	Measurement Frequency	Comment
Flooding	Date of drain for winter flooding (if applicable)	date	o	Annual	Farmer 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 look up values from the NRCS SSURGO database are not used, then data taken from field samples is required.

Table 6.2. Field Monitoring Parameters

Equation Reference	Parameter	Description	Data Unit	Calculated (c) Measured (m) Reference(r) Operating Records (o)	Measurement Frequency	Comment
Equation 5.1	ER	Total emission reductions from the project area for the reporting period	tCO_2e	c,m	Cultivation cycle	
Equation 5.1 Equation 5.3 Equation 5.4	PER	Total primary GHG emission reductions	tCO_2e	c,m	Cultivation cycle	
Equation 5.1 Equation 5.11	SE	Total secondary effect GHG emission reductions	tCO_2e	c,m	Cultivation cycle	
Equation 5.2 Equation 5.3	N_2O_i	Average cultivation cycle direct and indirect N_2O emissions from rice field *i*, equal to the average of the values of all Monte Carlo runs *j*	kg CO_2e/ha	c	Cultivation cycle	Note: In Equation 5.3 this parameter contains additional subscript denoting whether it pertains to the baseline or project scenario cultivation cycles.

Equation Reference	Parameter	Description	Data Unit	Calculated (c) Measured (m) Reference(r) Operating Records (o)	Measurement Frequency	Comment
Equation 5.2 Equation 5.3	$CH_{4\ i}$	Average cultivation cycle CH_4 emissions from rice field *i*, equal to the average of the values for all Monte Carlo runs *j*	kg CO_2e/ha	c	Cultivation cycle	Note: In Equation 5.3 this parameter contains additional subscript denoting whether it pertains to the baseline or project scenario cultivation cycles.
Equation 5.2 Equation 5.3	$SOC_{LDcc,i}$	Average cultivation cycle final soil organic carbon content of rice field *i* on the last day of either the baseline or project scenario cultivation cycle, equal to the average of the values for all Monte Carlo runs *j*	kg CO_2e/ha	c	Cultivation cycle	Note: In Equation 5.3 this parameter contains additional subscript denoting whether it pertains to the baseline or project scenario cultivation cycles.
Equation 5.2	$N_2O_{Dir,j,i}$	N_2O emissions from rice field *i* from Monte Carlo run *j*	kg N_2O-N/ha	c	Cultivation cycle	
Equation 5.2	$N_{Leach,j,i}$	Nitrate leaching loss from rice field *i* from Monte Carlo run *j*	kg NO_3-N/ha	c	Cultivation cycle	
Equation 5.2	$N_{Vol,j,i}$	Ammonia volatilization and nitric oxide emissions from rice field *i* from Monte Carlo run *j*	kg NH_3-N + kg NO_x-N /ha volatized	c	Cultivation cycle	
Equation 5.3	$Area_i$	Area of the rice field *i*	ha	m	Cultivation cycle	
Equation 5.4	PERud	Total primary GHG emission reductions from the entire project, corrected for uncertainty deductions	tCO_2e	c,m	Cultivation cycle	
Equation 5.4	μ_{struct}	Accuracy deduction from model structural uncertainty		r	Cultivation cycle	Values will be made available on Reserve website
Equation 5.4	$\mu_{inputs,i}$	Accuracy deduction factor for individual rice field *i* due to input uncertainties	fraction	c	Cultivation cycle	As calculated in Appendix B Step 5.1

Equation Reference	Parameter	Description	Data Unit	Calculated (c) Measured (m) Reference(r) Operating Records (o)	Measurement Frequency	Comment
Equation 5.5 Equation 5.11	$SE_{FF,i}$	Total secondary effect GHG emissions from increased fossil fuel combustion for field *i*	tCO_2e	c	Cultivation cycle	As calculated in Section 5.5
Equation 5.5	$EF_{HP\text{-}hr,i,f}$	Emission factors for fossil fuel emissions	g CO_2e/HP-hr	r	Cultivation cycle	
Equation 5.5	$HP_{i,f}$	Horsepower requirement for machinery operated *i* on field *f*	HP	r	Cultivation cycle	
Equation 5.5	$t_{i,f}$	Time required to perform operation *i* on field *f*	hr/field	m	Cultivation cycle	Note: Additional subscript is used to denote whether the parameter is used in the baseline or project scenario. In the baseline scenario, *j* is replaced by the letter *k*.
Equation 5.5 Equation 5.8	A_f	Size of field	ha	m	Cultivation cycle	
Equation 5.6	FF_j	Total change in fossil fuel consumption for field *f*, by fuel type *j*	gallons	m	Cultivation cycle	
Equation 5.7	$W_{RS,i}$	Total weight of rice straw in dry tonnes that is swathed, raked, and baled on the field *i*	dry tonne	m	Cultivation cycle	
Equation 5.7	EF_{SRB}	Emission factor for increased fossil fuel emissions from swathing, raking, and baling	tCO_2e / dry tonne	r	Cultivation cycle	
Equation 5.7	$W_{RS,U}$	Weight of rice straw in dry tonnes with end-use *U*. The sum weight of rice straw for all end-uses must equal the total weight of rice straw baled on the field	dry tonne	m	Cultivation cycle	
Equation 5.7 Table A.1	EF_U	Emission factor for end-use *U*	tCO_2e / dry tonne	r	Cultivation cycle	From Table A.1 in Appendix A

Equation Reference	Parameter	Description	Data Unit	Calculated (c) Measured (m) Reference(r) Operating Records (o)	Measurement Frequency	Comment
Equation 5.8	$Y_{f,t}$	Yield of field *f* in year *t*	Mg/ha	m	Cultivation cycle	
Equation 5.8	$Y_{county,t}$	County average yield in year *t*	Mg/ha	c	Cultivation cycle	
Equation 5.8 Equation 5.9	y_norm_t	Normalized yield for each year *t*	fraction	c	Cultivation cycle	
Equation 5.9	y_min	Minimum yield threshold below which normalized yields are significantly smaller than the historical average	fraction	c	Cultivation cycle	
Equation 5.9 Equation 5.10	$\Delta SOC_{B,i}$	Change in soil organic carbon content of rice field i during the baseline cultivation cycle	kg CO_2e/ha	c	Cultivation cycle	
Equation 5.10	SOC_{LDBcc}	Soil organic carbon stock value on the last day of the baseline cultivation cycle (i.e. the day harvest is complete)	kgC/ha	c	Cultivation cycle	
Equation 5.10	SOC_{FDBcc}	Soil organic carbon stock value on the first day of the baseline cultivation cycle (i.e. the day after the previous year's harvest is complete)	kgC/ha	c	Cultivation cycle	
Equation 5.11	$SE_{RM,i}$	Total secondary effect GHG emissions from alternative residue management for field *i*	tCO_2e	c	Cultivation cycle	As calculated in Section 5.5
Equation 5.11	SE_{PS}	Total secondary effect GHG emissions for the project aggregate from production shifting outside of the project boundary	tCO_2e	c	Cultivation cycle	As calculated in Section 5.5

7 Reporting and Record Keeping

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.

A field serial number must appear in the file name of all monitoring records for each distinct field and kept in accordance with this protocol (see Section 7.1.1 for details on how to create field serial numbers).

7.1 Project Submittal Documentation

For each rice cultivation project, project developers/aggregators must provide the following documentation to the Reserve in order to submit an RC project for listing on the Reserve.

- Project Submittal form
- Project Submittal *.csv file

The Project Submittal form is the same for both single-field projects and aggregates. Both single-field and aggregate projects are also required to submit a Project Submittal *.csv file, which shall include the initial "List of Enrolled Fields"; each field's serial number (according to Section 7.1.1 below), county and state; and the names of project participants for each field. In the case of a single-field project, the List of Enrolled Fields shall include only the single field. The List of Enrolled fields for aggregate projects shall include all fields enrolled in the aggregate at the time of submittal. Aggregate projects are required to update the List of Enrolled Fields prior to commencement of verification activities (i.e. prior to submission of the NOVA/COI), to include all fields actually enrolled in the aggregate at that point (e.g. if fields have been added or removed from the aggregate between submittal and contracting a verifier [53]). The list must also be updated prior to each subsequent verification.

Project submittal forms can be found at http://www.climateactionreserve.org/how/program/documents/.

7.1.1 Determining Field Serial Numbers

The field serial number, which must be included in the List of Enrolled Fields, shall be determined by the following algorithm, with each element separated by a dash (-):

First state postal abbreviation, followed by the first letter of the County, followed by degrees of the most north-western point of the field (latitude then longitude, both reported to four decimal places), followed by the acreage of the field.[54] (Example: CA-*B-39.6123-121.5332-76* would be a 76 acre field in Butte County, CA.)

7.2 Annual Reports and Documentation

Once a project has been listed, project developers must provide the following documentation to the Reserve in order to register an RC project. This documentation must be submitted to the

[53] See the Reserve Verification Program Manual at http://www.climateactionreserve.org/how/program/program-manual/.

[54] Because all fields are located in the United States, the latitude will always be positive (i.e. degrees north of the equator), and longitude will always be negative (i.e. degrees west of the Prime Meridian). Therefore, in the example serial number, the field in Butte County California is at *+39.6123º latitude, and -121.5332º longitude.*

Reserve within 12 months of the end of each reporting period in order for the Reserve to issue CRTs for quantified GHG reductions.

The following documentation is required of both single-field projects and aggregates:

- Signed Attestation of Regulatory Compliance form
- Signed Attestation of Voluntary Implementation form (initial verification only for single-field projects; aggregates, see guidance in Section 3.6)
- Signed Attestation of Title form or Aggregator Attestation of Title form[55]
- Annual reports (as outlined in Sections 7.2.1 and 7.2.2)
- Verification Report
- Verification Statement

With the exception of the annual reports, all of the above project documentation will be available to the public via the Reserve's online registry. Further disclosure (e.g. of the annual reports) and other documentation may be made available on a voluntary basis through the Reserve, at the request of the project developer.

In the event that a project participant transfers from one aggregate to a different aggregate, the new aggregator is responsible for submitting a Field Management Transfer form, which requires the project participant's signature, to the Reserve prior to the beginning of the subsequent reporting period. The new aggregator should also make sure to obtain and have on file all necessary documentation for the new field, as required by this protocol.

Project forms can be found at http://www.climateactionreserve.org/how/program/documents/.

7.2.1 Single-Field Report

For each cultivation cycle, project developers of single-field projects must include the following information in an annual report submitted to the Reserve as a *.csv file:

- The field serial number (see Section 7.1.1)
- The acreage of the field (acres)
- Start date of the field
- Whether the field had previously been enrolled in an aggregate
    - If so, include the name of the project aggregate and dates of enrollment
- The field's emission reduction calculation results for the current verified cultivation cycle (both corrected and uncorrected for model uncertainty)

7.2.2 Aggregate Report

For each cultivation cycle, all aggregate-level monitoring information must be included in an annual Aggregate Report that is submitted to the Reserve as a *.csv file, with accompanying documentation, at verification. The Aggregate Report must contain a list of all fields and the following information for each field:

- The field serial number (see Section 7.1.1)
- The acreage of the field (acres)

[55] Although the single-field project will submit the general Attestation of Title form, aggregators will be required to submit an Aggregator Attestation of Title form, which will include language attesting to the fact that the aggregator has not and will not knowingly allow a third party (e.g. project participant) to provide false, fraudulent, or misleading data or statements.

- Start date of the field
- Date field enrolled in the aggregate
    - Including a flag specifying whether the field is a new addition to the aggregate in the particular year
- Current status of field (active, terminated, transferred to a different aggregate) as well as a description of any notable changes in management control and/or management practices
- Name of project participant associated with the field
- A flag for which fields had site visit or desktop verifications, or were unverified, in the previous reporting period
- The emission reduction calculation results for each field (both uncorrected and corrected for uncertainty) for that calculation period
- 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)

7.2.3 Field Report

For each cultivation cycle, all fields within an aggregate must submit an annual Field Report to the aggregator. This report is not submitted to the Reserve. Although the Reserve encourages participants to submit a Field Report in the form of a *.csv file, the format of the report is at the discretion of the aggregator.

At a minimum, the Field Report is required to include the following:

- A signed statement by the project participant attesting to the fact that all statements and data contained therein are true and accurate
- Field management data (as specified in Section 6.4.2)
- Project activity data (as specified in Section 6.4.3)

7.3 Record Keeping

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

7.3.1 Record Keeping for Single-Field Projects

The project developer shall retain the following records and documentation, as well as documentation to substantiate the information in the annual Single-Field Report and all field-level data and calculations. These records include:

- Contractual arrangements with each project participant and/or land owner (if applicable)
- Copies of letters of notification sent to land owners, including the dates letters were sent
- GIS or KML shape files clearly defining the field boundary, as defined in Section 2.2.1
- Northwestern latitude/longitude coordinates of field (to four decimal places)
- Serial number of field (according to the guidance in Section 7.1.1)
- 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 DNDC output files (*dnd files)
- Copies of 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

- Executed Attestation of Title, Attestation of Regulatory Compliance, and Attestation of Voluntary Implementation forms
- Field management data (as specified in Section 6.4.2)
- Onsite fossil fuel use records
- Fertilizer purchase records
- Project activity data (as specified in Section 6.4.3), including:
  - All time-stamped digital photographs of the seeding, flooding, and baling activities
  - Rice baling logs
  - Rice straw sales receipts or contracts (if applicable)
  - All maintenance records relevant to the farm equipment and monitoring equipment
- Rice sales/milling records
- Copies of soil laboratory statements and the Soil Sampling Log (Appendix B, Step 1.4) for any sampled soil parameters
- Results of CO_2e annual reduction calculations
- Initial and annual verification records and results

7.3.2 Record Keeping for Project Aggregates

7.3.2.1 Aggregate-Level Record Keeping

The aggregator shall retain the following records and documentation, as well as documentation required by Section 6 to substantiate the information in the annual Aggregate Report. System information must be retained for each field, but collected and managed at the aggregate level. These records include all:

- Contractual arrangements with each project participant and/or land owner
- Copies of letters of notification sent to land owners, including the dates letters were sent
- GIS or KML shape files clearly defining the field boundaries, as defined in Section 2.2.1, of each distinct field in the aggregate
- Northwestern latitude/longitude coordinates for each field (to four decimal places)
- Serial numbers for each field (according to the guidance in Section 7.1.1)
- 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 DNDC output files (*.dnd files)
- Copies of 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
- Executed Aggregator Attestation of Title, Attestation of Regulatory Compliance, and Attestation of Voluntary Implementation forms
- Results of CO_2e annual reduction calculations
- Initial and annual verification records and results

7.3.2.2 Field-Level Record Keeping

The project developer/aggregator shall retain the following records and documentation, as well as documentation required in Section 6.4 for each field.

- Field management data (as specified in Section 6.4.2)
- Onsite fossil fuel use records
- Fertilizer purchase records

- Project activity data (as specified in Section 6.4.3), including:
    - All time-stamped digital photographs of the seeding, flooding, and baling activities
    - Rice baling logs
    - Rice straw sales receipts or contracts (if applicable)
    - All maintenance records relevant to the farm equipment and monitoring equipment
- Rice sales/milling records
- Copies of soil laboratory statements and the Soil Sampling Log (Appendix B, Step 1.4) for any sampled soil parameters

7.4 Reporting Period and Verification Cycle

Though the requirements for reporting periods vary slightly between single field projects and aggregates, reporting periods generally correspond to a single year-long cultivation cycle. Aggregate projects undergo verification annually, while single field projects may choose from multiple flexible options for the verification cycle upon completing the first verification as detailed below.

Project developers/aggregators must report GHG reductions resulting from project activities for all fields during each reporting period, which represents a complete cultivation cycle. A complete cultivation cycle may be slightly greater or less than 365 days for each field depending on planting/harvest dates.

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 30 of the next year. Each field must quantify their emission reductions for its entire cultivation cycle, and the aggregate reductions must be reported on the uniform reporting period. For project aggregates, no more than one reporting period can be verified at once.

Both reporting periods and cultivation cycles must be contiguous; there can be no time gaps in reporting during the crediting period of an aggregate or single field project once the initial reporting period has commenced.[56] Because a single reporting period spans two calendar years (from fall of one year to late summer/fall of the next year), a single “vintage” must be assigned for reporting purposes. The calendar year in which the rice crop is harvested is used as 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 a 2013 vintage.

7.4.1 Additional Reporting and Verification Options for Single-Field Projects

For single-field projects, however, there are three verification options to choose from, which provide the project developer more flexibility and help manage verification costs associated with RC projects. The project developer may choose from these additional options after a project has completed its initial verification and registration.

A project developer may choose to use one option for the duration of a project’s crediting period. Regardless of the option selected, reporting periods must be contiguous; there may be no time gaps in reporting during the crediting period of a project once the initial reporting period has commenced.

[56] An entire aggregate can willingly forfeit CRTs for an entire cultivation cycle in accordance with the zero-credit reporting period policy in section 3.3.3 of the Reserve Program Manual, available at http://www.climateactionreserve.org/how/program/program-manual/.

If a single-field project joins a project aggregate, that field is immediately subject to the verification schedule of the aggregate moving forward.

If a field exits a project aggregate to become a single-field project, that project is subject to the reporting and verification requirements of an initial reporting and verification period. In other words, that single-field project's first verification as a single-field project may not take advantage of Options 2 or 3, below.

7.4.1.1 Initial Reporting and Verification Period

The reporting period for projects undergoing their initial verification and registration cannot exceed one complete cultivation cycle. Once a project is registered and has had at least one complete cultivation cycle of emission reductions verified, the project developer may choose one of the verification options below.

7.4.1.2 Option 1: Twelve-Month Maximum Verification Period

Under this option, the verification period may not exceed one complete cultivation cycle, which may be slightly greater or less than 365 days. Verification with a site visit is required for CRT issuance.

7.4.1.3 Option 2: Twelve-Month Verification Period with Desktop Verification

Under this option, the verification period cannot exceed one complete cultivation cycle. However, CRTs may be issued upon successful completion of a desktop verification as long as: (1) Site visit verifications occur at two-year intervals; and (2) The verification body has confirmed that there have been no significant changes in selected project activities, field management or ownership and/or management control of the field since the previous site visit. Desktop verifications must cover all other required verification activities (i.e. a full desktop verification of the Single-Field Report).

Desktop verifications are allowed only for a single 12-month verification period in between 12-month verification periods that are verified by a site visit.

7.4.1.4 Option 3: Twenty-Four Month Maximum Verification Period

Under this option, the verification period cannot exceed two complete cultivation cycles (approximately 730 days or 24 months) and the project monitoring plan and Single-Field Report must be submitted to the Reserve for the interim cultivation cycle's reporting period. The project monitoring plan and report must be submitted for projects that choose Option 3 in order to meet the annual documentation requirement of the Reserve program. They are meant to provide the Reserve with information and documentation on project operations and performance. They also demonstrate how the project monitoring plan was met over the course of the first half of the verification period. They are submitted via the Reserve online registry, but are not publicly available documents. The monitoring plan and report shall be submitted within 30 days of the end of the reporting period.

Under this option, CRTs may be issued upon successful completion of a site visit verification for GHG reductions achieved over a maximum of 24 months. CRTs will not be issued based on the Reserve's review of project monitoring plans or reports. Project developers may choose to have a verification period shorter than 24 months.

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 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 or Certified Crop Advisor on the verification team in order to verify RC projects.

8.1 Preparing for Verification

The project developer is responsible for coordinating all aspects of the verification process, coordinating with the verification body, project participants (in the case of a project aggregate), and the Reserve, and submitting all necessary documentation to the verification body and the Reserve.

The project developer is responsible for selecting a single verification body for the entire project or project aggregate for each reporting period. The same verification body may be used up to six consecutive years (the number of consecutive years allowed, according the Reserve Verification Program Manual[57]). Verification bodies must pass a conflict-of-interest review against the project developer, and in the case of project aggregates, all project participants and the aggregator. Consequently, the submitted List of Enrolled Fields must be updated by the aggregator prior to the conflict of interest review.

Each year, project developers of single-field projects must make the Single-Field Report, which is submitted to the Reserve annually, and the Single-Field Monitoring Plan available to the verification body. These documents must meet the requirements in Sections 6 and 7.

In project aggregates, each year, project participants must submit all field data to the aggregator according to the guidelines in Sections 6 and 7. Aggregators must make all Field Monitoring Plans, the Aggregate Monitoring Plan, DNDC output files and the Aggregate Report available to the verification body.

[57] Available at http://www.climateactionreserve.org/how/verification/verification-program-manual/.

In all cases, the above documentation should be made available to the verification body after the NOVA/COI process is complete.

Aggregators may assist project participants in preparing documents for verification and in facilitating 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.

For project aggregates, a field is considered verified if it is in the pool of fields for which site visits or desktop verifications are conducted, even if not selected for either a site visit or desktop verification. 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 verification body all instances of field exclusion. The excluded fields shall be removed from the acreage totals and from field numbers used to determine field eligibility and verification sampling methodologies (in Section 8.2) and are therefore not considered verified.

8.2 Verification Schedule for Single-Field Projects

Single-field projects are comprised of exactly one field, and as such, there is no sampling methodology to select the fields undergoing verification. The single-field project shall be verified according to the verification schedule outlined below.

This protocol provides project developers three verification options, Sections 8.2.1 to 8.2.3, for a single-field project after its initial verification and registration in order to provide flexibility and help manage verification costs associated with rice projects. For each option, verification bodies may need to confirm additional requirements specific to this protocol, and in some instances, utilize professional judgment on the appropriateness of the option selected.

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

8.2.1 Option 1: Twelve-Month Maximum Verification Period

Option 1 does not require verification bodies to confirm any additional requirements beyond what is specified in the protocol.

8.2.2 Option 2: Twelve-Month Verification Period with Desktop Verification

Option 2 requires verification bodies to review the documentation specified in Section 7.4.1.3 in order to determine if a desktop verification is appropriate. The verifier shall use their professional judgment to assess any changes that have occurred related to project data management systems, equipment or personnel and determine whether a site visit should be required as part of verification activities in order to provide a reasonable level of assurance on the project verification. The documentation shall be reviewed prior to the NOVA/COI renewal submitted to the Reserve, and the verification body shall provide a summary of its assessment and decision on the appropriateness of a desktop verification when submitting the NOVA/COI renewal. The Reserve reserves the right to review the documentation provided by the project developer and the decision made by the verification body on whether a desktop verification is appropriate.

8.2.3 Option 3: Twenty-Four Month Maximum Verification Period

Under Option 3 (see Section 7.4.1.4), verification bodies shall look to the project monitoring report submitted by the project developer to the Reserve for the interim 12-month reporting period as a resource to inform its planned verification activities. While verification bodies are not expected to provide a reasonable level of assurance on the accuracy of the monitoring report as part of verification, the verification body shall list a summary of discrepancies between the monitoring report and what was ultimately verified in the List of Findings.

8.3 Verification Sampling and Schedule for Project Aggregates

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 verification body using random sampling, according to the verification schedule and sampling methodologies outlined in Sections 8.3.1, 8.3.2, and 8.3.3. These sampling methodologies establish the minimum verification frequencies; the verification body may at any time add fields beyond the minimum number required for site visit and/or desktop 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 verification body to work together to develop a cost-effective and efficient site visit schedule. Specifically, once the sample fields designated for a site visit have been determined, the verification body shall document all fields selected for planned site visit verification and provide a list 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 verification body with all the required documentation to demonstrate field-level conformance to the protocol. When a verification body determines that additional sampling is necessary, due to suspected non-compliance, however, a similar level of advance notice may not be possible.

Aggregators and project participants shall not be made aware, in advance, of which fields' data will be subject to desktop 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 8.3.1, 8.3.2, and 8.3.3.

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 desktop verification frequency requirements based on a verification schedule determined by the verifier, in compliance with Section 8.3.1 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 desktop verification, according to the sampling method in Section 8.3.2, 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 desktop verification, according to the sampling method in Section 8.3.3, 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 visits and desktop verifications, the verification body shall round up to the nearest whole number.

The actual requirements for performing a site visit verification and desktop verification are the same. A desktop verification is equivalent to a full verification, without the requirement to visit the site. A verification body has the discretion to visit any site in any reporting period if the verification body determines that the risks for that field warrant a site visit. Any site visits initiated at the discretion of a verifier shall be in addition to the required site visit verification schedule.

8.3.1 Verification Schedule for Small Aggregates

8.3.1.1 Site Visit Verification Schedule for Small Aggregates

Each field in a small aggregate shall undergo 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 percent 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:

- 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)
- A minimum of 20 percent of the fields in the aggregate shall be site verified in any given year, selected at random

8.3.1.2 Desktop Verification Schedule for Small Aggregates

In any given year, a number of desktop verifications of field data must be conducted, with the number inversely related to the number of fields undergoing a site visit that year. Specifically, the number of desktop verifications (**D**) shall equal 50 percent of the number of fields (**n**) 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,

$$\boldsymbol{D = \frac{(n - S)}{2}}$$

Where,

n	=	Number of fields in the aggregate
S	=	Number of site visits
D	=	Number of desktop verifications

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

8.3.2 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 desktop verification, during its entire crediting period. Therefore, random sampling is a particularly important component of enforcement.

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

The verification body 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 (**n**) enrolled in the large single-participant aggregate that year (i.e. $\boldsymbol{S} = \sqrt{\boldsymbol{n}}$ rounded up to the nearest whole number).

8.3.2.2 Sampling for Desktop Verification for Large Single-Participant Aggregates

In addition to site visit verifications, verification bodies shall randomly select a sample of fields to undergo a desktop verification (**D**) equal to two times the square root of the total number of fields in the aggregate.

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

8.3.3 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 desktop verification selection. However, the verification body shall select fields for site visits first as described in Section 8.3.3.1 and desktop verifications second as described in Section 8.3.3.2.

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

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

The verification body shall determine the number of project participants that must be randomly selected for a site visit in a given year, as follows:

$$\boldsymbol{S} = \left(\mathbf{1} + \left(\frac{\boldsymbol{P}}{\mathbf{500}}\right)\right) \times \sqrt{\boldsymbol{P}}$$

Where,

S	=	Number of project participants that must receive site visits
P	=	Number of project participants in the aggregate

The verification body shall randomly select (**S**) project participants to receive site visits that year.

The verification body shall select which fields of the selected project participants will receive a site visit. For project participants with six enrolled fields or fewer, the verification body shall site visit at least 50 percent of the fields, selected at random. For project participants with more than six fields enrolled in the aggregate, the verification body shall site visit at least 33.3 percent of the fields, selected at random.

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 to 3, then the verification body 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.

8.3.3.2 Sampling for Desktop Verification for Large Multi-Participant Aggregates

In addition to site visit verifications, each year verification bodies shall also randomly select fields to undergo a desktop verification of their field data. Verification bodies shall randomly select a sample of fields to undergo a desktop verification 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 desktop verification, the verification body will continue randomly drawing additional fields until the total number selected for a desktop verification reaches the square root of the total number of fields in the aggregate.

8.4 Standard of Verification

The Reserve's standard of verification for RC projects is the Rice Cultivation 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 Sections 2 through 7 of this protocol. Sections 2 through 7 provide eligibility rules, methods to calculate emission reductions, performance monitoring instructions and requirements, and procedures for reporting project information to the Reserve.

8.5 Monitoring Plan

The Aggregate Monitoring Plan and Field Monitoring Plan serve as the basis for verification bodies to confirm that the monitoring and reporting requirements in Sections 6 and 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 and Table 6.2 are collected and recorded.

8.5.1 Annual Reports

The single-field project's project developer must annually submit field data for single-field projects to the Reserve. The Single-Field Report will consist of a *.csv file and attachments, as described in Section 7.2.1. Verification bodies must review the Single-Field Report to confirm project information and data collected according to the SFMP.

The project aggregate must annually submit an Aggregate Report to the Reserve. The report will consist of a *.csv file and attachments, as described in Section 7.2.2. Verification bodies must review the Aggregate Report to confirm project information and data collected according to the AMP.

The verification body will need to review field data during desktop verifications of randomly selected fields in an aggregate. The field data must be made available to the verification body in order to confirm field-level information collected according to the FMP.

8.6 Verifying Eligibility at the Field Level

Verification bodies must affirm each project field's eligibility during site visit and/or desktop verifications according to the rules described in this protocol. Table 8.1 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. Projects must be submitted for listing before the end of the first cultivation cycle in which the project activity is implemented.	Once during first verification
Location	All fields must be located in the California rice growing region.	Once during first verification
	Must not include fields with SOC greater than 3% in the top 10 cm.	Every verification
	Must not include fields that have been treated with nitrification inhibitors, urea inhibitors or controlled release fertilizers.	Every 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 Attestation of Voluntary Implementation form and monitoring procedures for ascertaining and demonstrating that the project passes the Legal Requirement Test.	Single Field Project: once during first verification Aggregate: once during first verification and once during first verification for new fields that have joined aggregate
Legal Title to CRTs	Aggregator Attestation of Title to CRTs.	Every verification
Regulatory Compliance	Signed Attestation of Regulatory Compliance form and disclosure of all non-compliance events to verification body; project must be in material compliance with all applicable laws.	Every verification

8.7 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:

- Identifying emission sources, sinks, and reservoirs
- Reviewing GHG management systems and estimation methodologies
- 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 single-field project or 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 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 8.3.2.1, to ensure systems on the ground correspond to and are consistent with data provided to the verification body, combined with a random sample of desktop verifications of remaining project fields according to Section 8.3.2.2. 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 confirm 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 whether the appropriate modeling structural uncertainty factors (Section 5.4.3) and yield-loss statistical tests (Section 5.5.3) have been performed for the aggregate.

8.8 Project Type Verification Items

The following tables provide lists of items that a verification body needs to address while verifying a 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.

8.8.1 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 single requirement is not met, either for one or more fields, then the entire aggregate may be determined ineligible or the GHG reductions from the reporting period (or subset of the reporting period) may be ineligible for issuance of CRTs, as specified in 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	Yes
2.3	Verify ownership of the reductions by reviewing Aggregator 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
3.4	Verify that all verified fields have a SOC content less than 3% in the top soil	No
3.5.1	Verify that each field meets the Performance Standard Test	No
3.5.2	Confirm execution of the Attestation of Voluntary Implementation form to demonstrate eligibility under the Legal Requirement Test	No
3.5.3	Verify that any ecosystem service payment or credit received for activities on a project field has been disclosed and is allowed to be stacked	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

Protocol Section	Eligibility Qualification Item	Apply Professional Judgment?
6.1, 6.2, 6.3	Verify that the project Monitoring Plan contains a mechanism for ascertaining and demonstrating that all fields pass the Legal Requirement Test at all times	No
6.1, 6.3, 6.4	Verify that field-level and aggregate-level monitoring meets the requirements of the protocol. If it does not, verify that a variance has been approved for monitoring variations	No

8.8.2 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 aggregate 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
5.4.2	For the aggregate, verify that all field emission reductions are summed correctly, and that the structural uncertainty factor is properly applied	No
5.4.3.3 and Appendix B Step 5	For each field, verify that the soil input uncertainty discount is quantified and applied correctly	No
5.5.1	Verify that the aggregator correctly monitored, quantified and aggregated fossil fuel and electricity use changes	Yes
5.5.2	For each field, verify that baled rice straw end-uses are properly characterized, and the appropriate emission factors are used	Yes
5.5.3	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
Appendix B Step 1.2	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
Appendix B Step 1.2	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
Appendix B Step 2.1	Confirm that the missing data substitution methodology has been applied correctly	Yes
Appendix B Step 3	For each field, verify that the DNDC model is adequately calibrated to historical yields, and that the 20-year historical calculation was run correctly	Yes
Appendix B Step 4	For each field, verify that the Monte Carlo analysis was performed correctly for the baseline and project modeling runs for each field	No

8.8.3 Risk Assessment

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

Table 8.4. Risk Assessment Verification Items

Protocol Section	Item that Informs Risk Assessment	Apply Professional Judgment?
6	Verify that 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
6.1, 6.2, 6.3	Verify that the project has documented and implemented the Single-Field Monitoring Plan or Aggregate Monitoring Plan, and all necessary Field Monitoring Plans	No
6.1, 6.2, 6.3	Verify that the project monitoring plans are sufficiently rigorous to support the requirements of the protocol and proper operation of the project	Yes
6.4	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 GHG reporting duties	Yes
7.2	Verify that the Single-Field Report or Aggregate Report was uploaded to the Reserve software	No
7.2, 7.3	Verify that field data has been gathered by project participants and made available to the aggregator	No
7.3	Verify that all required records have been retained by the project developer	No

8.9 Successful and Unsuccessful Verifications

Successful verification of each field in the sample of fields selected for site visit and desktop verifications 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."

8.9.1 Field-Level and Project Participant-Level Errors

If material issues arise during verification of a participating field, verification bodies 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 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 percent of the total emission 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 verification body 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 verification body shall site visit a minimum of two additional fields or 50 percent 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 their 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 verification body shall use their professional judgment and a risk-based assessment to determine whether sampling additional project participants for site visit verification, beyond the minimum requirements of this protocol, is necessary to verify the entire aggregate to a reasonable level of assurance.

8.9.1.1 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 Verification Program Manual. Should the aggregated error and/or non-compliance rate for the sampled fields be less than 5 percent, CRT issuance for fields not subjected to site visit or desktop 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 percent, CRT issuance for fields not subjected to site visit or desktop verification shall be reduced by the total amount of aggregated percent error or non-compliance rate.

8.9.2 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 regard to the model input parameters or a quantitative error repeated in multiple field-level model runs), the verification body 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.

8.10 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	Practices that are above and beyond “business as usual” operation, exceed the baseline characterization, and are not mandated by regulation.
Aggregator	A project developer responsible for a project comprising multiple fields.
Anaerobic	Pertaining to or caused by the absence of oxygen.
Anthropogenic emissions	GHG emissions resulting from human activity that are considered to be an unnatural component of the Carbon Cycle (i.e. fossil fuel destruction, deforestation, 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 initial adoption of this protocol by the Reserve Board: December 14, 2011.
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).
Field checks	Low dikes that are employed by rice farmers to control water distribution to their fields.
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, t)	A common international measurement for the quantity of GHG emissions, equivalent to about 2204.6 pounds or 1.1 short tons.
Methane (CH_4)	A potent GHG with a GWP of 21, consisting of a single carbon atom and four hydrogen atoms.
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 GHG emissions or emission reductions have met the minimum quality standard and complied with the Reserve's procedures and protocols for calculating and reporting GHG emissions and emission reductions.
Verification body	A Reserve-approved firm that is able to render a verification statement 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 Factors

The emission factors included in Table A.1 below were derived based on the conservative use of best available information regarding emissions associated with the transport and decay of rice straw given various end-use scenarios. Transportation energy use data came primarily from California rice straw time and motion studies[58] that examined, through survey responses within the industry, the costs associated with collection, storage, and transport of rice straw to various end-uses (primarily for use as cattle feed). Because of the uncertain nature of these emissions factors, the Reserve consistently applied conservative assumptions to estimate each emission factor, as described in the footnotes to Table A.1. A conservative default factor for 'unknown' or 'non-specified' offsite management has been included for cases where the ultimate fate of the rice straw is unknown.

Table A.1. Rice Straw End-Use Emission Factors

Rice Straw End-Use	Emission Factor (tCO_2e/t baled straw)
Unknown (or 'other' offsite management)	0.083 [1]
Dairy and Beef Cattle Feed	0.075 [2,4]
Fiberboard Manufacturing	0 [5]
Spread on Bare Soils for Erosion Control	0.012 [2,3]
Unused (left piled/stacked onsite)	0.210 [6]
1. Using survey responses from California rice baling experts, end-use emission 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 emission factor. The scenario that is used assumes that close to 100% of rice straw goes to Dairy and Beef Cattle Feed, with negligible amounts going to other end-uses. The resulting estimate of 75 kg CO_2e/t of baled straw was increased by 10% for conservativeness 2. Transportation emissions per MT of rice straw are estimated as being 13.14 kg CO_2e using the following assumptions:[58] a. Bales are transported 200 km b. Average truck capacity of 16 MT rice straw c. Diesel fuel efficiency of 6 MPG d. The emission factor for Diesel Fuel Use is 10.15 kg CO_2e/gal[59] 3. Anaerobic decay is unlikely because the straw is spread across the landscape, therefore maximizing oxygen availability during decomposition 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 an energy content of CH_4 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	

[58] Transport distance and truck capacity assumptions are conservative estimates based on information from time and motion studies in California (Jenkins et al. (2000), Table 3).
[59] US EPA (2008) Climate Leaders Greenhouse Gas Inventory Protocol Core Module Guidance: Direct Emissions from Mobile Combustion Sources, Appendix B, pg 26.

Avoidance of harvesting and transport of wood products provides likely net-positive GHG benefits 6. Equal to the IPCC default emission factor for aerobic composting (0.10 kg CH_4/t input). Low N residues (such as rice straw) would have discounted fugitive emissions compared with other compostable organic residues (Brown et al., 2008).	

Appendix B Step by Step Guide to Modeling RCPP Emissions Using DNDC

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 this appendix. Table B.1 below provides an overview of the process to model primary GHG emissions for this protocol using DNDC, as well as references to additional guidance.

Table B.1. Overview of DNDC Modeling

<table>
<tr><th>STEP</th><th>DNDC MODELING OVERVIEW</th><th>ADDITIONAL INFORMATION</th></tr>
<tr><td colspan="3">Step 1: Become familiar with necessary DNDC inputs</td></tr>
<tr><td>Step 1.1 Overview of DNDC site input parameters</td><td>This section introduces two typologies used to categorize DNDC input parameters.</td><td rowspan="5">DNDC User’s Guide (Version 9.5)

Appendix C</td></tr>
<tr><td>Step 1.2 Defining project inputs and static inputs</td><td>This section provides guidance on how to classify DNDC inputs as either project inputs or static inputs and where to source data for such inputs depending on their classification.</td></tr>
<tr><td>Step 1.3 Climate input parameters</td><td>This section provides guidance on climate input parameters.</td></tr>
<tr><td>Step 1.4 Soil input parameters</td><td>This section provides guidance on soil input parameters, including further guidance on:
▪ Using soil inputs from the SSURGO database
▪ Using soil inputs from field samples</td></tr>
<tr><td>Step 1.5 Cropping input parameters</td><td>This section provides guidance on cropping input parameters, including multiple subcategories of cropping inputs: crop, tillage, fertilization, manure amendments, irrigation and flooding.</td></tr>
<tr><td colspan="3">Step 2: Prepare input files</td></tr>
<tr><td>Step 2.1 Missing climate or soil data</td><td>This section provides a methodology to substitute data in the event that discrete climate or soil data is missing.</td><td></td></tr>
<tr><td>Step 2.2 Historical modeling</td><td>This section provides guidance on how to prepare the necessary historical data needed to model emissions and to calibrate the DNDC model.</td><td>DNDC User’s Guide (Version 9.5)

Appendix C</td></tr>
<tr><td>Step 2.3 Preparing DNDC input files</td><td>This section provides guidance on how to create separate input files for the baseline and project scenarios, that each contains data from both the baseline year and the project scenario.</td><td>DNDC User’s Guide (Version 9.5)

Appendix C</td></tr>
<tr><td colspan="3">Step 3: Calibrate the DNDC model</td></tr>
<tr><td>Calibrating the DNDC model</td><td>This section provides guidance on how to prepare DNDC for modeling by undertaking the calibration exercises.</td><td>DNDC User’s Guide (Version 9.5)

Appendix C</td></tr>
</table>

Step 4: Model emissions using DNDC		
Step 4.1 Modeling emissions using Monte Carlo simulations	This section provides guidance on how to conduct Monte Carlo simulations using the DNDC model, in order to calculate primary emissions for the baseline and then repeat the process to calculate primary emissions for the project scenario.	*DNDC User's Guide* (Version 9.5) Appendix C
Step 4.2 Extracting DNDC modeling results for calculating emission reductions	This section provides guidance on how to extract data from DNDC Monte Carlo run results and use that data to calculate primary emission reductions for each of the baseline and project scenarios respectively.	
Step 5 Calculate the soil input uncertainty deduction		
Calculating soil input uncertainty	This section provides guidance on how to use the results of the same Monte Carlo runs used to model emissions in order to calculate the soil input uncertainty deduction for each field.	Appendix C

Step 1.1 Overview of DNDC Site Input Parameters

The DNDC model must be properly parameterized with appropriate field-level data related to climatic drivers, soil characteristics and data on various rice cultivation management actions. DNDC's Graphical User Interface (GUI) divides the parameters required for modeling GHG emissions into three main categories: climate, soil, and cropping inputs. Within the cropping input parameter classification are six additional subcategories, for a total of eight parameter categories. For the purposes of quantifying emission reductions under this protocol, these DNDC input parameter categories are classified into two types; static input parameters and project input parameters. The distinction denotes whether data for those parameters must be sourced from the project scenario cultivation cycle only or both the project scenario cultivation cycle and the baseline scenario cultivation cycle. This classification is not reflected in the GUI, but rather explained and detailed in the protocol. Determining what parameters are categorized as "static" versus "project" input parameters is discussed in Appendix B Step 1.2.

When entering data into DNDC, project developers first use the DNDC GUI. Once a particular dataset has been entered into the GUI, the data should be saved as an input file. Whenever the project developer wishes to re-enter this field's data into the model in the future, he/she should do so by selecting this input file to be input into the model. The input file is also one of a number of digital resources that is necessary for monitoring, reporting, and verification (as discussed further in Sections 6, 7, and 8). The input files created by project developers contain data on all of the parameters required by DNDC, except for climate data. Separate input files are created for climate data in accordance with the formatting requirement stipulated in Appendix B Step 1.3 on climate input parameters. However, the input file can reference the relevant climate data files required to model the desired scenario, allowing DNDC to automatically draw climate data from existing data files. Project developers need to ensure they reference the 20 historical climate input files in correct order (i.e. the five historical years, repeated four times, in that specific order). Additional guidance on use of input files can be found in the User's Guide for the DNDC Model Version 9.5 and in Appendix B of this protocol. Additional guidance on the requirements for the historical 20 year period can be found in Appendix B Step 2.3.

Once project developers become familiar with the DNDC model, they can more efficiently alter the input text files manually so that most data will not need to be input using the DNDC GUI.

Some values will still need to be manually input into the DNDC GUI each time, as described in the sections below.

No DNDC default parameters shall be altered (i.e. values changed or data input where no values existed), unless explicitly directed to do so by this protocol. This can result in an incorrect parameterization of the DNDC model.

This section outlines which of these parameters are 'project' input parameters and which are static. The section then gives further guidance on the DNDC input parameters, according to the climate, soil and cropping DNDC GUI classification.

Table B.2 provides an overview of all of the DNDC input parameter subcategories and identifies which contain project and/or static inputs.

Table B.2. Overview of DNDC Input Parameters

Parameter	Static or Project Input Parameter?	Description	Source of Data for Project Cultivation Cycle Scenario	Source of Data for Baseline Cultivation Cycle Scenario
Climate	Static	Climatic variables	Project scenario cultivation cycle	Project scenario cultivation cycle
Soil	Static	Soil conditions	SSURGO data or, where unavailable, from project scenario cultivation cycle soil samples	SSURGO data or, where unavailable, from project scenario cultivation cycle soil samples
Cropping	Static	Cropping systems and cycles – rotations, etc.	Project scenario cultivation cycle	Project scenario cultivation cycle
Crop	Project/ Static	(1) Types of crops (2) Planting/harvest dates (3) Crop residue management (4) Crop physiology/phenology (DNDC default values used)	Project scenario cultivation cycle and DNDC defaults or values obtained from the UC Davis Jenkins Lab[60]	Residue Management = PROJECT input, taken from baseline scenario cultivation cycle All other inputs = STATIC inputs, taken from project scenario cultivation cycle and DNDC defaults or values obtained from the UC Davis Jenkins Lab[61]
Tillage	Project	Timing and method	Project scenario cultivation cycle	Baseline scenario cultivation cycle
Fertilization	Project	Must choose manual application	Project scenario cultivation cycle	Baseline scenario cultivation cycle
Manure amendment	Static	Timing, type and amount of soil amendments	Project scenario cultivation cycle	Project scenario cultivation cycle

[60] This information can be sourced directly from UC Davis. See http://ucanr.edu/sites/UCRiceProject/.
[61] Ibid.

Irrigation	Static	Use the DNDC default irrigation index value of 1	Project scenario cultivation cycle	Project scenario cultivation cycle
Flooding	Project	Must use irrigation option (Control 1) to input data	Project scenario cultivation cycle	Baseline scenario cultivation cycle

Step 1.2 Defining Project Inputs and Static Inputs

For the purposes of this protocol, all DNDC model inputs are classified into two types: project inputs and static inputs. As stated above, the distinction denotes whether data for those parameters must be sourced from the project scenario cultivation cycle only or both the project scenario cultivation cycle and the baseline scenario cultivation cycle.

Project inputs are those that relate to the management parameters that are being changed as a result of the project activity. Project inputs to the DNDC model are the only parameters that may vary when modeling baseline and project emissions to determine the GHG reductions related to the field's management change. For example, when modeling dry seeding, the only change would be the dates for when flooding up occurred (and perhaps added irrigation events to get germination), but other project inputs may remain unchanged (and thus be treated as static inputs). 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 versus project emission scenarios over the reporting period.

Static inputs may change from year to year, and therefore must be set using measured data from the cultivation cycle of the reporting period undergoing quantification. However, the value for a static input for any single cultivation cycle is assumed to be the same for both project and baseline scenarios.

Table B.3 lists all of the project input parameters.

Table B.3. List of Baseline Project Inputs

Baseline Practice	Project Input
Flooding at seeding	Dates of flooding relative to the planting date (other than winter flooding)
Residue Management	Fraction of straw removed after harvest (0 if no straw removed)
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

Step 1.3 DNDC Climate Input Parameters

Table B.4 summarizes the climate parameters for which data must be input into DNDC by project developers to model emission reductions.

Table B.4. Climate Parameters

Input Parameters	Unit	Default or Site-Specific?
Jday (Julian day)[62]	Day of year	Site-specific
MaxT (maximum temperature)	°C	Site-specific
MinT (minimum temperature)	°C	Site-specific
Precipitation	cm/day	Site-specific
Humidity	%	Site-specific
Wind speed (daily average)	meters/second/day	Site-specific
N concentration in rainfall	Mg	Default
NH_3 background atmospheric concentration	µg N/m^3	Default
CO_2 background atmospheric concentration	ppm	Default

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, or the nearest station to the field if there are none within 20 miles. 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).[63]
- Weather data for the five years preceding the start of the crediting period must be collected. Weather data for the 20-year historic period modeling run (see Appendix B Step 2.3) must be set by repeating this five-year weather data set four times.
- Daily values of maximum temperature, minimum temperature, precipitation, relative humidity and wind speed must be collected and formatted according to DNDC's climate file mode 6 format (see Table B.5 below).
- Default values for N concentration in rainfall, NH_3 background concentration and CO_2 background concentration shall be obtained from the National Atmospheric Deposition Program.[64] Project developers shall select an appropriate default value based on any given day during the first reporting period, which shall be used for the entire crediting period.

Data for N concentration in rainfall, NH_3 background concentration and CO_2 background concentration, are input directly into the DNDC GUI and will thus be contained in input files created by DNDC. Data for the remaining climate input parameters can only be input into the model via the use of climate input files that the project developer must create. When creating the climate input files for these variables, the data must be ordered in the precise manner set out in Table B.4 above, as outlined in the DNDC GUI file format default field. In other words, data needs to be input in text files in the following format: Jday, MaxT, MinT, Precipitation, Humidity, Wind Speed, Humidity.

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[62] A Julian Day calendar provided by NASA can be viewed here: http://www-air.larc.nasa.gov/tools/jday.htm. See also Section 5.3.

[63] Note that not all weather stations include data on all the requisite parameters, in particular wind speed and relative humidity, and so may not be a suitable source of climate data.

[64] See http://ucanr.edu/sites/UCRiceProject/. For the NADP see: http://nadp.sws.uiuc.edu/.

For example, the data for the first four days would appear in the input file looking as follows:

Table B.5. Required Formatting for Climate Input Files

1	14	12.1	5.2	4	0.028	0.032	0.048
2	18	11.1	6.2	4	0.029	0.031	0.042
3	13	10.1	7.2	4	0.023	0.033	0.047
4	12	11.1	8.2	5	0.025	0.032	0.048

Step 1.4 DNDC Soil Input Parameters

Table B.6 summarizes the soil parameters for which data must be input into DNDC by project developers to model emission reductions.

Table B.6. DNDC Soil Input Parameters

Input Parameters	Unit	Default or Site- Specific?
Clay content	Fraction	Site-specific
Bulk density	g/cm^3	Site-specific
Soil pH	pH	Site-specific
Soil organic carbon (SOC) at surface soil (0-10 cm)	kg C/kg soil	Site-specific
Soil texture	Fraction	Default

Some soil parameters affect methane emissions to a significant extent. Therefore, for each of the individual rice fields, values for the input parameters listed in Table B.6 must be obtained either from the USDA NRCS SSURGO data set, or based on soil measurements. The Reserve strongly advises project developers to use the SSURGO database, as this will avoid the resource expenditure needed for soil sampling and may reduce the uncertainty surrounding soil sampling results.

Data for the first four soil input parameters listed in Table B.6 needs to be sourced from the SSURGO database. A default soil texture input shall be selected from a drop down menu directly within the DNDC GUI. Project developers must choose a value from the drop down menu that most closely corresponds to the clay content fraction in the soil. Once entered into the DNDC GUI, data for all soil input parameters appears in the relevant DNDC input file.

Note that there are multiple additional soil data input points in the DNDC GUI for which default parameters are provided by DNDC. Unless specifically stated above, such defaults should not be altered.

Further guidance is given below regarding the use of soil data obtained from either the SSURGO database or field sampling.

Using Soil Data Inputs from the SSURGO Database

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. Figure B.1 below illustrates this concept for a rice field in Yolo County.

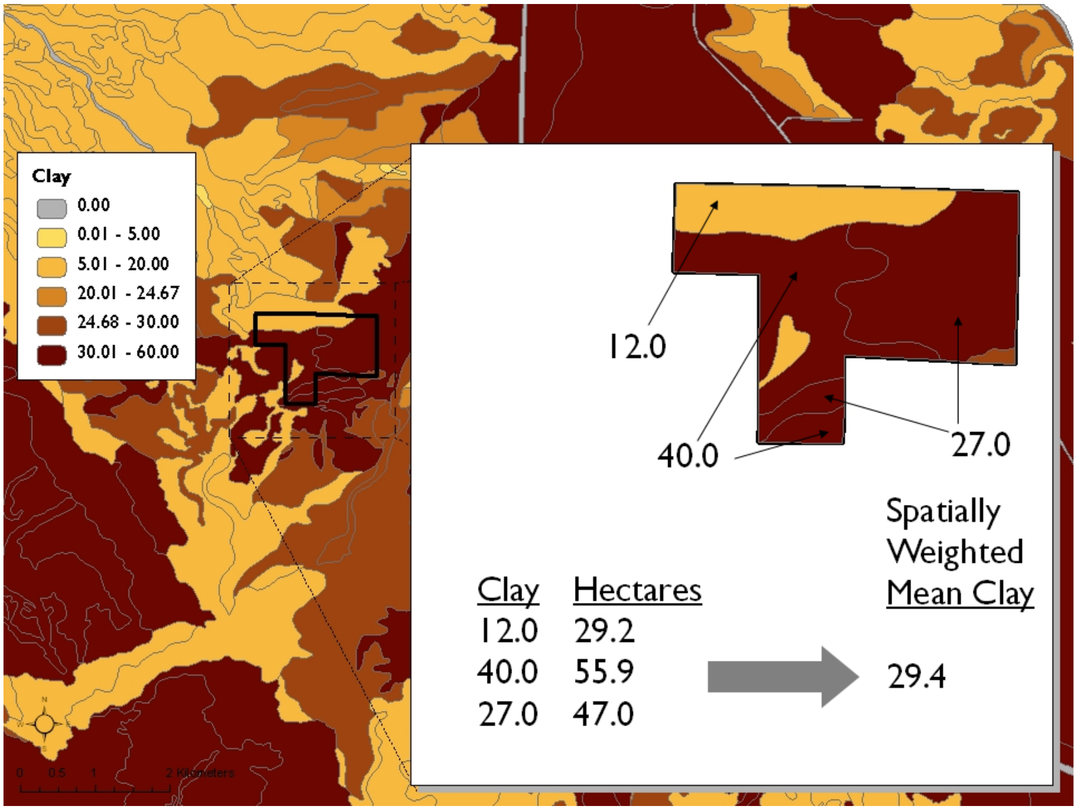

Figure B.1. Example of Soil Parameter Area-Weighting using SSURGO Data

Using Soil Inputs from Samples

If using soil measurements, data may not be older than 10 years prior to the field project start date and must meet the criteria for soil sampling outlined below. Official soil laboratory statements must be available during the verification process.

DNDC requires inputs of soil organic carbon content, soil bulk density, pH and clay fraction of the top 10 cm. If collecting samples for analysis (i.e. not using SSURGO data), the following procedure must be used for each field:

- Samples must be collected at a depth of 0-10 cm
- Samples must be collected using a core method
- 20 samples must be collected for the entire field
- To ensure spatial independence of soil properties, use a random sampling pattern
- Samples should be combined into one composite sample
- The GPS coordinates and depth at each sampling location must be recorded
- The combined 0-10 cm samples must be tested for all parameters
- Soil samples must be analyzed by a certified soil laboratory

A suggested mass of soil of at least 500 g should be collected from each depth for the initial (i.e. time zero) sampling. Future soil sample mass can be adjusted for the assessments being conducted.

Soil samples should be kept cool in the field and during transport. Samples should be maintained at 4°C as much as possible during processing. Samples should be sent to a soil lab for measurement of SOC, clay fraction, pH and bulk density.

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 third-party soil sampling contractor (if applicable)
- The name/address of the certified soil laboratory used for analysis

Step 1.5 DNDC Cropping Parameter Subcategories: Management Parameters

Cropping input parameters capture data on the approved project activities, and are therefore crucial in modeling emissions under this protocol. As set out in Appendix B Step 1.1, the Cropping input parameter category is made up of six subcategories, namely Crop, Tillage, Fertilization, Manure Amendment, Irrigation and Flooding.

Table B.7 summarizes the six subcategories of cropping parameters, referred to as crop management parameters, for which data must be input into DNDC by project developers to model emission reductions.

Table B.7. DNDC Cropping Parameters by Subcategory

Crop Input Parameters	**Unit**	**Default or Site-Specific?**
Planting date	Date	Site-specific
Harvest date	Date	Site-specific
C/N ratio of the grain	Ratio	Default
C/N ratio of the leaf + stem	Ratio	Default
C/N ratio of the root tissue	Ratio	Default
Fraction of leaves + stem left in field after harvest	Fraction	Site-specific
Maximum biomass (yield)	kg dry matter/ha/yr	Site-specific
Thermal degree days (TDD)	°C	Default
Biomass fraction	Fraction	Default
Water demand	g water/g dry matter	Default
Tillage Input Parameters		
Number of tillage events	Number	Site-specific
Date of tillage events	Date	Site-specific
Depth of tillage events	cm	Site-specific
Fertilization Input Parameters	**Unit**	
Number of fertilizer applications	Number	Site-specific
Date of each fertilizer application	Date	Site-specific
Application method	Surface/injection	Site-specific
Type of fertilizer	Type	Site-specific
Fertilizer application rate	kg N/ha	Site-specific
Manure Amendment Input Parameters		
Number of organic applications per year	Number	Site-specific

Date of application	Date	Site-specific
Type of organic amendment	Type	Default
Application rate	kg C/ha	Site-specific
Amendment C/N ratio	Ratio	Site-specific
Irrigation Input Parameters		
Number of irrigation events	Number	Site-specific
Date of irrigation events	Date	Site-specific
Irrigation types	Types	Default
Amount of water applied	cm	Site-specific
Flooding Input Parameters		
Date of flood-up for growing season	Date	Site-specific
Date of drain for crop harvest	Date	Site-specific
Date of flood-up for winter flooding (if applicable)	Date	Site-specific
Date of drain for winter flooding (if applicable)	Date	Site-specific

Crop Input Parameters

Default values for biomass fraction at maturity, biomass C/N ratio at maturity (i.e. C/N ratio of grain, leaf+stem, and root tissue, respectively), water demand and N fixation index are provided within DNDC for most rice cultivars and can be found in the "C:\DNDC\Library\Lib_crop" directory. The "crop.lst" file provides the look-up table for each crop. Where DNDC defaults are not available for the particular rice cultivar in use on a given field, data for biomass fraction, biomass C/N ratio, water demand[65] and N fixation index[66] should be obtained from UC Davis Jenkins Lab. The Thermal degree days value, defined as the cumulative air temperature from seeding to maturity of the crop, will need to be manually input based on default values sourced from UC Davis Jenkins Lab.[67]

The maximum biomass parameter is site-specific and refers to the maximum grain yield (measured in kg dry matter/ha/yr) which has been recorded for each field for the given cultivation cycle. Once this value is set in the GUI, the model will automatically create maximum biomass values for leaf, stem and root. Maximum yields are used in model calibration (see Appendix B Step 3) and in modeling emissions (see Appendix B Step 4).

When entering the fraction of leaves and stem left in the field after harvest, the project developer must ensure they provide sufficient evidence to their verifier to demonstrate their chosen value is appropriate. The provision of time/date stamped photographs of the height of the cutting blades used, close up photos of the residues in the field etc., may be helpful in this regard.

Tillage Input Parameters

The number and date of tillage events needs to be set based on field observations. The depth of tillage events parameter is set based on defaults provided in the DNDC GUI. When setting the depth of tillage events in DNDC, the project developer must set the value closest to the tillage method they used. The project developer needs to retain sufficient evidence to demonstrate to

[65] Water demand represents the amount of water needed for the crop to produce a unit of dry matter of biomass (in g water/ g dry matter).
[66] While the default N fixation index is 1 for non-legume crops, it must be calculated for legume crops, such as rice. The N fixation index is equal to the ratio (total N content in the plant)/(plant N taken from soil).
[67] This information can be sourced directly from UC Davis. See http://ucanr.edu/sites/UCRiceProject/.

their verifier that they have chosen an appropriate default value. Photographic evidence and interviews with relevant staff may be useful in this regard.

Fertilization Input Parameters

The number, date, method and rate of fertilizer application events need to be set based on field observations. DNDC accepts seven types of fertilizers: urea, anhydrous ammonia, ammonium nitrate, nitrate, ammonium bicarbonate, ammonium sulfate, and ammonium phosphate. Where a project developer has used a fertilizer that combines several of these products, they will need to ensure that they enter the correct amount of each of these types of fertilizers. This information can typically be found on fertilizer packaging or by contacting the manufacturer, an agronomist, or a university agricultural extension officer.

Manure Amendment Input Parameters

DNDC allows for data on any soil amendment to be input into the model, and provides default parameters (i.e. C/N ratio) for several types of soil amendments. Project developers must use the DNDC default values for the soil amendments listed, unless no suitable DNDC defaults are provided. If no suitable DNDC default value is provided, project developers must provide verifiers with sufficient material to justify the use of any alternative value.

Irrigation Input Parameters

The number, date, and rate of irrigation events need to be set based on field observations. Project developers must select the “flood irrigation” type within the DNDC GUI, as this is the only type relevant to rice cultivation.

Flooding Input Parameters

The date of all flooding events needs to be set based on field observations. Note that flooding events that carry over from December to January of the next year must be set to end on December 35 in the DNDC GUI in order to be recorded correctly in the model.

Step 2.1 Missing Climate or Soil Data

The DNDC model will crash if instructed to run without a full set of data for each input parameter. In situations where portions of the climate or soil input data are missing, the project developer must apply the data substitution methodology outlined in this section. This methodology may also be used for periods when the project developer can show that the data are available but known to be corrupted or inaccurate (and where the corruption/inaccuracy can be verified with reasonable assurance). For periods when it is not possible to use the data substitution procedure below to fill gaps, no emission reductions may be claimed.

Missing Climate Data

The method used to correct or complete missing climate data depends on a number of factors, including:

- The length of time that data were missing
- Availability of data from alternative sources
- The climate variable that is being corrected

For gaps in climate data that do not exceed 14 days, project developers shall use the average value of the previous and following 14 days from the same source of data. For gaps that are longer than 14 days, project developers shall use data for that same region from another source, or data from the nearest alternative weather station.

Missing Soil Data

If using SSURGO data for soil input parameters and data is missing in relation to one or more parameters, then project developers shall use data from the STATSGO database for those missing data. If data to replace the missing data is not available from the STATSGO database, then data must be sourced from field samples.

If using field samples for all soil inputs, and some data is missing, the project developer must either resample for those parameters or use data from the SSURGO database. Where SSURGO data is unavailable, data from the STATSGO database may be used.

Step 2.2 Historical Modeling

When preparing DNDC for modeling (i.e. calibrating the model, as discussed in Step 3 below) and when using DNDC to model emissions for both the project and baseline scenarios, historical data must be input into the model. This is necessary to ensure DNDC has adequate background data to accurately model emissions. The rules for using historical data depend on whether the data is being used for calibration or for modeling emissions.

When performing calibration, five years of historical data from the years immediately prior to the start date of the project must be used. No baseline or project scenario data are needed for calibration (other than for observed yield, as set out in Step 3 below). The same 5 years of data from the 5 years prior to the start of the project will be used as the historical period for the duration of the project.

When modeling emissions, each time DNDC is run to calculate either the baseline scenario or project scenario emissions for a given cultivation cycle, it must be run using data from the cultivation cycle being modeled as well as 20 years of historical data, for a total of 21 years of data. The input parameters for the 20-year historical period are set by repeating all parameters from the five years before the start of the project four times.

Additional guidance on using input files to create this 20-year historical period is provided in Appendix C and the *DNDC User's Guide* Version 9.5. Table B.8 below provides an overview of this process.

Table B.8. Schematic of Modeling and Calibration Periods

<table>
<tr><th>Year
-20 to -15*</th><th>Year
-15 to -10*</th><th>Year
-10 to -5*</th><th>Year
-5 to 0</th><th>Year
0 to 5</th><th>Year
5 to 10</th></tr>
<tr><td colspan="4">Historical Period</td><td colspan="2" rowspan="2">Crediting Period</td></tr>
<tr><td colspan="4">Model Equilibration</td></tr>
<tr><td colspan="3"></td><td>Crop Yield Calibration</td><td>Crediting Period 1</td><td>Crediting Period 2</td></tr>
</table>

Source: Figure adapted from Proposed VCS Methodology: Calculating Emission Reductions in Rice Management Systems.
* Represented by repeating historical parameter values for years -5 to 0.

Step 2.3 Preparing DNDC Input Files

As indicated in the Step 2.2 guidance above, each time DNDC is used to model emissions for either the baseline or project scenario, it requires 21 years of data. Inputting the requisite 21 years of data can be done using a single input file.

When entering data into DNDC, project developers first use the DNDC GUI. Once a particular dataset has been entered into the GUI, the data should be saved as an input file. Whenever the project developer wishes to re-enter this field's data into the model in the future, he/she should do so by selecting this input file to be input into the model. The input file is also one of a number of digital resources that is necessary for monitoring, reporting, and verification (as discussed further in Sections 6, 7, and 8).

The input files created by project developers contain data on all of the parameters required by DNDC, except for climate data. Separate input files are created for climate data in accordance with the formatting requirement stipulated in Appendix B Step 1.3 on climate input parameters. However, the input file can reference the relevant climate data files required to model the desired scenario, allowing DNDC to automatically draw climate data from existing data files. Project developers need to ensure they reference the 20 historical climate input files in correct order (i.e. the five historical years, repeated four times, in that specific order). Additional guidance on use of input files can be found in the User's Guide for the DNDC Model (Version 9.5) and in Appendix C of this protocol. Additional guidance on the requirements for the historical 20 year period can be found in Appendix B Step 2.2.

Once project developers become familiar with the DNDC model, they can more efficiently alter the input text files manually so that most data will not need to be input using the DNDC GUI. Some values will still need to be manually input into the DNDC GUI each time, as described in the sections below.

No DNDC default parameters shall be altered (i.e. values changed or data input where no values existed), unless explicitly directed to do so by this protocol. This can result in an incorrect parameterization of the DNDC model.

Step 3 Calibrating the DNDC Model

Prior to modeling baseline and project emissions for the first reporting period for each field, the DNDC model must be calibrated in order for the model to attain equilibrium in certain critical variables for which empirical data are lacking, such as the sizes and quality of the different carbon pools, and the inorganic nitrogen contents of soil pore water. This calibration step only needs to be performed once for the duration of the project, for each field.

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 and CH_4 and N_2O emissions.

Users shall calibrate the DNDC crop model for cropping systems to be included in the project. Figure B.2 outlines the steps for crop calibration.

When undertaking the calibration process, the majority of data on soil input parameters comes from the historical baseline period (i.e. the five years immediately prior to the project start date):

- Maximum grain yield (kg dry matter/ha) shall be set based on the highest observed yield in the five year historical baseline period
- TDD value shall be manually input based on data obtained from UC Davis Jenkins Lab[68]
- Soil texture class shall be manually set based on the observed clay fraction in the soil

The remaining soil values shall be set manually based on DNDC defaults. Where DNDC defaults are not available for the particular rice cultivar in use on a given field, defaults shall be obtained from UC Davis Jenkins Lab.[69]

The steps for crop calibration are outlined below. Calibrating the DNDC model is an iterative process. To carry out the calibration process, the project developer must first run a five year simulation using data from the historical baseline period for that field. Once the simulation has been run, the project developer must then extract crop yields for the five years from the annual summary file. The project developer shall compare the difference between modeled outputs and observed yield for those five years. The maximum biomass and the thermal degree day parameters of the DNDC model must be manually adjusted so that DNDC predicts the maximum recorded yield during the five years before the start of the project with a maximal relative Root Mean Squared Error (RMSE) of 10 percent of the observed mean.

To achieve this calibration, the project developer must use the following process for the single year out of the historic five years that had the maximum observed rice yield.

1. **Adjust maximum biomass parameter:**
    a. Enter observed maximum biomass
    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 the recorded yields during the five years before the start of the project observed grain yield should be within a maximal relative Root Mean Squared Error (RMSE) of 10 percent of the observed mean. If the difference is greater than 10 percent, keep repeating steps (i) and/or (ii) below, until the result is below 10 percent. It is suggested that the user should alter the maximum biomass value by a percentage similar to the observed difference, in order to arrive at a properly calibrated result:
        i. If the difference is greater than 10 percent and the modeled grain yield is less than the actual yield, increase the maximum biomass parameter
        ii. If the difference is greater than 10 percent and the modeled grain yield is greater than the actual yield, decrease the maximum biomass parameter

2. **Adjust cumulative thermal degree days (TDD):** Check the modeled maturity date which can be found in the "Day_FieldCrop.csv" file.[70] The modeled maturity date must be brought to within seven days of the harvest date, for the model to be effectively

[68] This information can be sourced directly from UC Davis. See http://ucanr.edu/sites/UCRiceProject/.
[69] Ibid.
[70] 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 Graphical User Interface (GUI).

calibrated.[71] The last column of this file, "GrainC," shows daily grain weight (kg C/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 more than seven days later than the harvest date, you will need to reduce the TDD value
b. If the modeled maturity date is more than seven days earlier than the harvest date, you will need to increase the TDD value

Figure B.2 below illustrates this calibration process.

[71] It is not necessary for the difference between observed and modeled TDD to be within seven days for each of the five historical years, but rather that the average over the five years be within seven days.

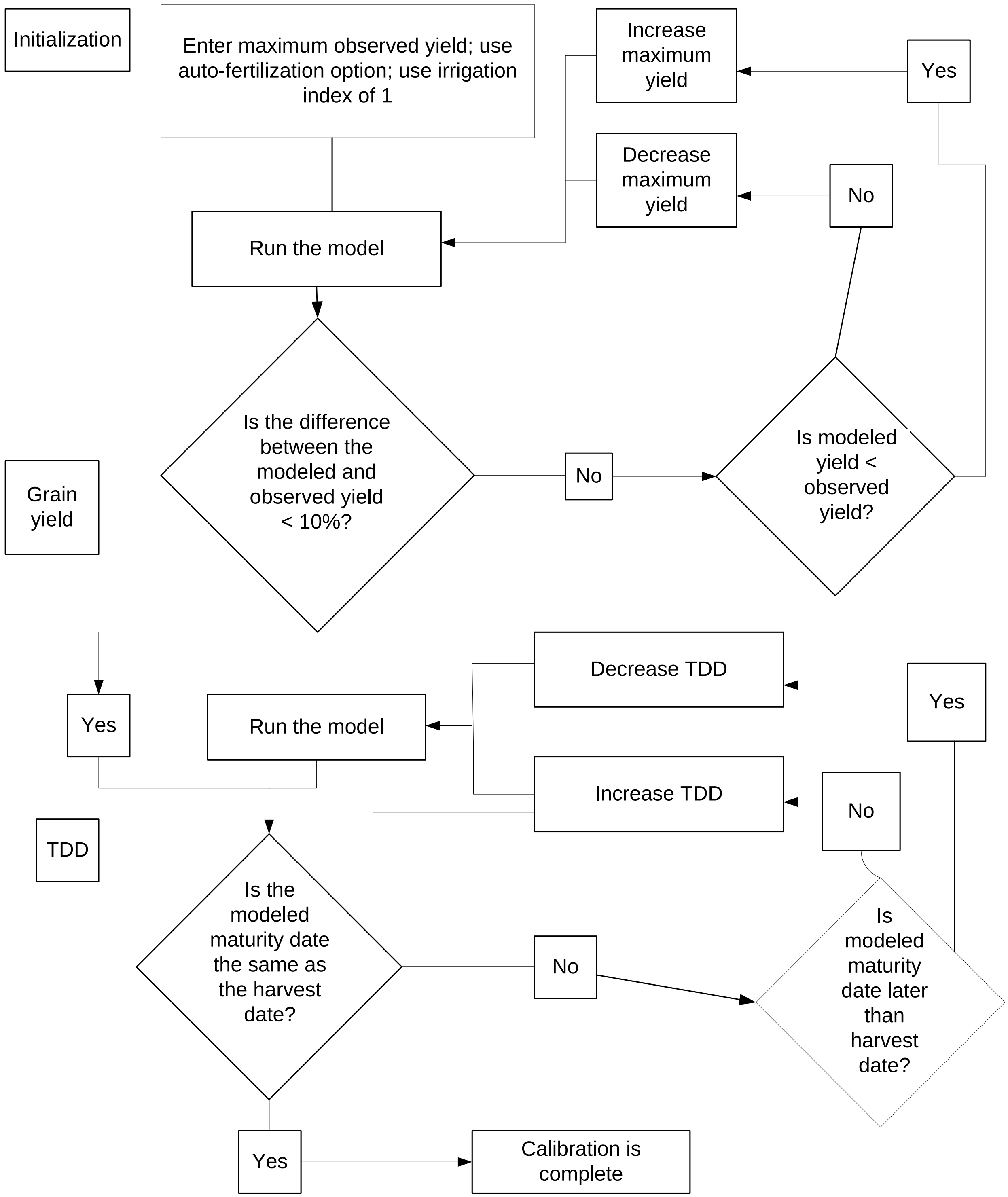

Figure B.2. Calibrating the DNDC Model

Step 4.1 Modeling Emissions using Monte Carlo Simulations

To calculate emissions reductions, project developers need to first model emissions from the baseline scenario and then model emissions from the project scenario. These emissions are compared to calculate associated emission reductions. This section outlines the process for modeling the emissions.

For this protocol, the DNDC model must be run using Monte Carlo batch runs to calculate emission estimates for a given cultivation cycle. A full set of 2,000 Monte Carlo runs must be performed for each calendar year within the baseline scenario and then a full set of 2,000 Monte Carlo runs must be performed for each calendar year within the project scenario.

Monte Carlo simulations are a class of computational algorithm that rely on repeated random sampling within a set range of input values to compute results. Monte Carlo simulations are particularly useful when there is uncertainty with respect to data inputs, as thousands of runs can be performed quickly, an average result determined, and the variance in results calculated. The duration of each Monte Carlo run should be the same as the duration of the cultivation cycle for the field (i.e. approximately 365 days).The Monte Carlo runs are 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* Version 9.5, for more information).

For each field, a Monte Carlo simulation of 2,000 model runs shall be performed for each calendar year within both the baseline cultivation cycle and the project cultivation cycle corresponding to the current reporting period. For each of these 2,000 baseline cultivation cycle and 2,000 project scenario cultivation cycle runs, the project developer needs to input data for both the 20-year historical period and the cultivation cycle being modeled (see Appendix B Step 1.2 for further guidance on sourcing data for project and static input parameters). Once the Monte Carlo simulation has been run using 21 years of data, results from the modeling of the 20 year historical period shall be ignored; only the results from the 21st year (i.e. the cultivation cycle in either the project scenario or the baseline scenario being modeled), are used.

It should be noted that modeling 21 years, as instructed, can be done using one single input file. Refer to Appendix B Step 2.3 and the *DNDC User's Guide* Version 9.5 for further guidance on developing input files, Appendix B Step 1.2 for guidance on sourcing data for project and static input parameters and Appendix B Step 2.3 for guidance on how to set a 20-year historical baseline period appropriate to each crediting period.

Once the Monte Carlo simulations are complete, results are recorded in a *.csv file. The name of the file shall be the site name as entered into DNDC. Project developers are strongly encouraged to use naming conventions for DNDC files based on the field serial number methodology described in Section 7.1.1.

Note that DNDC saves the results from each Monte Carlo batch run into both annual summary files and daily summary files. When quantifying emission reductions and calculating the soil input uncertainty deduction, results need to be extracted from the daily results files, and only for those dates that fall within each field's cultivation cycle.

Specifying Monte Carlo Analysis Soil Input Uncertainty

This protocol allows project developers the choice of using soil survey data (i.e. SSURGO) or field soil samples to estimate soil conditions. The method for parameterizing DNDC for Monte

Carlo analyses depends on whether SSURGO or directly measured soil data are used as inputs.

If NRCS SSURGO soil survey data[72] are used for setting soil parameter values, then default uncertainty estimates shall be set based on the uncertainty estimates and probability distribution functions (PDF) listed in Table B.9. For each soil stratum, the mean value shall be calculated as the area-weighted sum of the representative values for all of the relevant SSURGO data.

Table B.9. Uncertainty Estimates and Probability Distribution Functions for Soil Parameters

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

Source: Selected from http://www.abdn.ac.uk/modelling/cost627/Questionnaire.htm.

If field measurements are used, then the uncertainty level for each soil parameter shall be +/- 10 percent of the mean at a 90 percent confidence level.

Step 4.2 Extracting DNDC Modeling Results for Calculating Emission Reductions

The DNDC GUI creates estimates of primary emissions that occurred over the given year being modeled; however the model uses emission factors not employed by this protocol. Therefore, it is important that project developers do not extract emissions estimates from the DNDC user interface, but instead extract data from the daily *.csv files to manually generate emission results for the baseline and projects scenarios separately, using the emission factors stipulated in Equation 5.2.

It is also important that project developers understand that the entire modeling process must be undertaken twice for each cultivation cycle being modeled, once for the calendar year within which the cultivation cycle starts, and again for the subsequent calendar year in which the cultivation cycle ends. Section 5.3 provides further explanation of the need to model two calendar years of emission reductions for each cultivation cycle.

At the conclusion of a modeling exercise (for either the baseline or project scenario), the project developer extracts data from 2,000 separate results files for the 21st year being modeled, [73] for each calendar year being modeled. Specifically, from the daily *.csv files, project developers shall extract the direct GHG emission parameter values (N_2O, CH_4, and SOC content), and the indirect parameter values (NO_3 and NH_3+NO_x). The SOC and CH_4 values (expressed in DNDC as SOC and CH_4*flux* respectively) shall be extracted from the Day_SoilC file. Data on all of the nitrogen-related parameters (i.e. N_2O, NO_3, and NH_3+NO_x) shall be extracted from the Day_SoilN file.

The DNDC *.csv files contain data for each of the Julian days being modeled for a calendar year (i.e. approximately 365 days of data in each results file). From each of the 4,000 results files (2,000 from each calendar year), the project developer must extract data for only those dates

[72] See http://soils.usda.gov/survey/geography/ssurgo/.
[73] As explained in Step 4.1, the first 20 years of data/results are for historical modeling only.

that fit within the field's cultivation cycle. The results for the cultivation cycle are then added together (for all parameters except SOC; SOC values are taken only for the last Julian day in the cultivation cycle), such that the project developer has a single value for each GHG parameter for the cultivation cycle, for each of the 2,000 Monte Carlo runs. Once these values have been generated they must be averaged according to Equation 5.2 in Section 5.4.1. At the end of this process, the project developer has a single value for each key GHG parameter, representing the average value for that parameter for the cultivation cycle across all of the Monte Carlo runs.

This process must be repeated for both the baseline scenario and the project scenario.

Step 5 Calculating Soil Input Uncertainty

Project developers shall sum together primary emissions for the baseline scenario (CH_{4B} + N_2O_B + $\Delta SOC_{B,I}$),[74] and then sum together primary emissions for the project scenario (CH_{4P} + N_2O_P + ΔSOC value for the project scenario).[75] 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 percent confidence interval of the difference between the baseline and project scenario cultivation cycle primary emissions, where the primary emissions for each Monte Carlo run *j* are expressed as a percent of the mean GHG cultivation cycle emissions of field *i.*

The soil input uncertainty deduction is used in Equation 5.4 to correct the total modeled primary emission reductions for soil input uncertainty.

Further guidance on the development of soil input uncertainty deductions is provided in Appendix C.

[74] Using CH_{4B} and N_2O_B from Equation 5.3 and $\Delta SOC_{B,I}$ from Equation 5.10, with each parameter converted into CO_2 equivalents.
[75] Using CH_{4P} and N_2O_P from Equation 5.3 and deriving a ΔSOC value for project scenario, in the same manner as the baseline ΔSOC value is derived in Equation 5.10, with each parameter converted into CO_2 equivalents.

Appendix C RCPP General Quantification Guidance

Quantification Guide Index:

Introduction

This appendix is intended to be a practical guide for users of the DNDC model. As such, this appendix includes information that is not strictly needed for this protocol (for instance guidance on using the DNDC model for pre-project feasibility analyses).

This guide describes the use of the DNDC model for the Reserve Rice Cultivation Project Protocol (RCPP). This guide assumes a basic familiarity with the model and its use and is meant to be used in conjunction with the *User's Guide for the DNDC Model* (Version 9.5) (*DNDC User's Guide*), which explains the background mechanics of the model as well as the functionality of the DNDC graphical user interface (GUI).

Development of Ex Ante Input Data and Assessment of Offset Potential

Prior to developing rice offset projects, project developers may want to assess opportunities prior to implementing projects. Such assessments are not required for this protocol. This assessment entails several steps, including collection of current agricultural management data, *ex ante* modeling of general baseline emissions and a suite of mitigation options, and first order assessment of economic feasibility of the mitigation measures.

The first step in developing rice offset projects and applying the DNDC model to evaluate the potential magnitude of emission reductions requires collection of basic rice management data (plant/harvest dates, flooding/irrigation and tillage practices, fertilizer use, etc). Collection of soils and climate data for DNDC modeling is discussed below.

Farmers decisions regarding when to plant rice, how much fertilizer to apply, when to till the soils, when to flood and when to harvest are driven by a combination of factors including commodity prices, prices of resources (e.g. fertilizer) and weather patterns. Over a crop season it is possible that farmers have a good estimate of commodity prices and cost of inputs. However, climatic conditions and associated impacts on agricultural management decisions are difficult to predict prior to the growing season. We also know that management practices and weather both have a significant impact on greenhouse gas (GHG) emissions from agricultural soils.

Given the reliance on weather patterns for decisions regarding agricultural management practices, the *ex ante* modeling is based on an estimation of what the growers think they will do in the future. The *ex ante* input data on management (see detailed discussion below on DNDC model inputs) for the baseline scenario should be based on recent management practices to satisfy both the performance standard criteria and simplify *ex ante* calculations. Once the baseline management practices are set, the project developers can assess what eligible mitigation measures they wish to implement by running DNDC with those changes in management that are both economically viable and have potential to reduce GHG emissions. Later in this document we present an example of the mechanics in using DNDC to evaluate potential offset management changes.

Once a project is implemented, the project developer must collect all of the necessary input data for running the DNDC model. These data are collected through the growing season to insure that the data reflect exactly what the farmer did. The change in approved practice changes implemented by the project must be represented in the model inputs. The key to reliable and genuine project modeling is to define what and how management practices are changed under the project scenario.

Collection of Climate Data for DNDC Modeling

The DNDC model requires daily data on maximum and minimum temperature, precipitation and average wind speed. In California, these data can be collected from the CIMIS (California Irrigation Management Information System) network of weather stations.

Collection of Climate and Soil Data for DNDC Modeling

DNDC requires inputs of soil organic carbon content, soil bulk density, pH and clay fraction of the top 10 cm. Data on soil conditions for a given field can either be collected from existing soil surveys (NRCS SSURGO) or through direct measurement. The RCPP describes some general guidelines on soil sampling for measuring soil properties for DNDC model simulations.

Calculation of Input for *Ex Post* Offset Calculations

The *ex ante* calculations are just an estimate of the potential reductions from implementing one or more of the approved project activities. The *ex post* calculations, performed in accordance with Section 5.4.1 of the RCPP, determines the primary effect GHG reductions that occur on a field due to RC project activity. Once a farmer implements a project and changes management practices from what they would have done in the "baseline," the baseline becomes a fictitious scenario that represents what the grower "would have done" in the absence of the RC project.

The *ex post* model simulations are done for both the project management practices (what was actually done and recorded by the project) and the "baseline" management. The baseline management practices are the same as the project except for the specific changes in management selected for the project (e.g. those management practices that are recognized as approved project activity practices in Section 2.2 of the RCPP). Because *ex post* calculations represent the real reductions achieved at the field over the course of a complete cultivation cycle, actual weather data must be used for the *ex post* model simulations.

Example: Assessing Impact of Input Uncertainties on Modeled Offsets

This section describes how to calculate the impact of input uncertainties on DNDC modeled emission reductions following the procedures summarized in Section 5.4.2 of the RCPP. Input uncertainty must be quantified when using the DNDC model because the DNDC model can be sensitive to changes in input parameters, specifically changes in soil conditions. The Monte Carlo Input Uncertainty assessment models the GHG emissions thousands of times for a specific field, with each model run using slightly different soil parameters. The soil parameters for each Monte Carlo run are randomly selected based on the probability distribution function (PDF) expected for each soil input used to parameterize the model. Project developers can choose to use either the SSURGO database or field sampling to characterize the soil input parameters.

The following example demonstrates the Monte Carlo modeling approach described in Appendix B Step 4.1 of the RCPP. To apply this method for assessing the impact of uncertainty of soil conditions, the first step entails defining a possible range and probability distribution of the soil conditions. For this example, we use soil databases developed by the U.S. Department of Agriculture Natural Resources Conservation Services (USDA NRCS). The general approach is to assume some variability in site soil attributes (clay fraction, organic matter fraction, bulk density, and pH) as modeled in the USDA NRCS SSURGO soil model. Using a Monte Carlo simulation, one must model identical crop management practices and meteorological conditions while varying soil conditions through the expected range of conditions. The current uncertainty tool in DNDC allows users to run thousands of model simulations in a Monte Carlo mode for most input parameters. However, the current tool in the model assumes an *even* distribution (PDF) for each parameter. The RCPP requires the Monte Carlo run to assume a *log-normal* distribution of each of the soil attributes as well as some amount of correlation between them. The three steps for running the model in Monte Carlo mode can be described as:

- An analysis of correlation between the four soil attributes. In the development of the RCPP an analysis of SSURGO soil data for over 6000 rice fields was completed to develop default correlation coefficients for key soil input parameters. The default correlation coefficients are provided in Table C.1 below.
- Programmatic generation of DNDC inputs based on the Monte Carlo method and pre-defined correlation coefficients.
- Running the DNDC model in site mode using the batch processing option and synthesizing the results.

We demonstrate this approach in two ways; the first assumes no correlation between soil parameters, which is conservative since we know that there is significant correlation between soil parameters. The second set of Monte Carlo runs utilized correlation statistics as part of the sampling procedure.

Soil attributes are stored within the SSURGO database according to the following relationships:

Horizon	Contains soil attribute data (low, representative, and high values) based on an assessment of soil field conditions
⇩	[one to many]
Component	The basic soil type (roughly equivalent to soil series) – soil components have many horizons and have no explicit spatial location
⇩	[one to many]
Map Unit	The smallest mapped polygon in the SSURGO model – soil map units have many components of varying fractions

To assess correlation among soils in rice growing areas of California, all map units intersecting rice fields as mapped in the California Department of Water Resources land use database were selected. From this selection, we identified all soil components contained within the map units. Soil attribute data came from the top horizon for each component. Thus, the final database represents all soil horizons intersecting rice fields.

Pearson correlation coefficients we calculated for each set of pairs for representative values of the four soil attributes:

Table C.1. Soil Correlation Coefficients

	Clay fraction	OM fraction	Bulk Density	pH
Clay Fraction	1	-	-	-
OM Fraction	0.139	1	-	-
Bulk Density	-0.526	-0.685	1	-
pH	0.263	0.098	-0.126	1

The Monte Carlo simulation should randomly generate 2,000 numbers for each of the four soil properties with the correlation matrix and with each following a log-normal distribution. This can be done by using the Cholesky decomposition of the correlation matrix to transform a set of standard-normal random numbers in the logarithm space. The representative value are used as the mean, while the low and high values are transformed into log space and treated as a range of +/- 3 standard deviations. This will result in four sets of 2,000 correlated random numbers, normally distributed. The soil properties, other than pH, are then calculated by taking the exponent of the numbers.

The DNDC model should then be run as a batch using the DNDC site mode (see *DNDC User's Guide*). To demonstrate this, we ran two scenarios (one with a winter flood, one without a winter flood) for a single field as follows:

- Rice planted May 1, harvested September 11
- Tillage on April 23, April 26, April 27, April 29, and September 15
- Fertilizer on April 30 (injected anhydrous ammonia), May 1 (surface application of $(NH_4)_2HPO_4$), May 26 (surface application of $(NH_4)_2SO_4$)
- Flooded from May 1 to September 1
- Winter flood from November 15 to January 31 (only for the winter flood scenario)
- Rice straw burned once every eight years

These results indicate the modeled methane emissions and net GHG emissions are quite sensitive to soil conditions. At 90 percent confidence interval, the range in modeled CH_4 and net

GHG emissions were significant (over 14 percent in both baseline and project simulations) (see Table C.2 below). However, the impact of soil uncertainties on modeled changes in emissions from baseline to project conditions were quite small (<3 percent). Figure C.1 below shows the histogram of the Monte Carlo simulation results for the case assuming no correlation between soil input parameters. It is clear for this baseline and project scenario, that uncertainty in soil input parameters impacted both baseline and project modeled emissions in a similar degree. Accounting for correlation between soil input parameters reduced uncertainties. The table below summarizes these results.

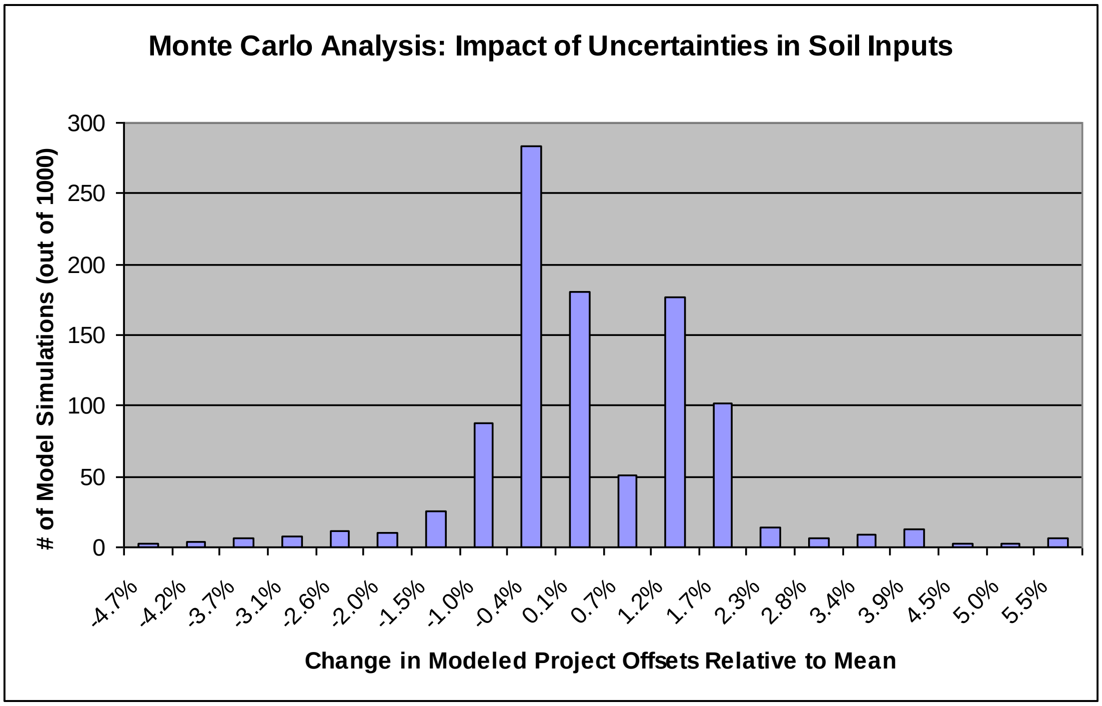

Figure C.1. Change in Modeled Offsets Based on Running Monte Carlo Analysis on Soil Input Uncertainty

Table C.2. Uncertainty in Modeled GHG Emissions and Change in Emissions at 90 Percent Confidence Interval due to Uncertainty in Soil Values

	Assuming No Correlation in Soil Input Parameters		Accounting for Correlation of Soil Input Parameters	
	CH_4 GWP (90% CI / Mean)	Total GHG GWP (90% CI / Mean)	CH_4 GWP (90% CI / Mean)	Total GWP (90% CI / Mean)
Baseline	14.7%	14.4%	14.0%	13.7%
Project	18.5%	20.0%	17.5%	19.1%
Baseline-Project	**1.0%**	**2.2%**	**0.2%**	**1.4%**

DNDC Modeling Overview

This section of the guide is a general overview of the modeling process to give the user a sense of the steps involved in evaluating various land management scenarios. It presents material on gathering input data for the model, using the DNDC GUI to enter data, setting up appropriate soil conditions for the model, calibrating parameters for crops, viewing results, and estimating model uncertainty.

Sources of Data

Prior to running the DNDC model, numerous input data are required, including information on soil, meteorology (climate), and management practices. As DNDC looks principally at soil dynamics, accurate soil parameters are critical: at a minimum, users should gather precise data for soil organic matter content (kg C/kg soil), bulk density (g/cm^3), soil texture (soil clay fraction can be used as a proxy here), and pH. Daily meteorological data for the modeling timeframe should include maximum and minimum air temperatures (°C) and precipitation (cm).

Creating Site Input Files

Once the user has gathered natural conditions and management information for the site, DNDC input files can be created using the DNDC GUI. The user will enter information for the following twelve thematic areas:

- Site
- Climate
- Soil
- Farming rotation management
- Crop
- Tillage
- Fertilization
- Manure amendment[76]
- Irrigation
- Flooding
- Plastic mulch (not relevant for RCPP)
- Grazing and cutting (not relevant for RCPP)

For a step-by-step guide to data input, the user may refer to the *DNDC User's Guide*, Section III-1.1.

Crop Model Calibration

Crop simulation plays a crucial role in modeling carbon and nitrogen biogeochemistry in and greenhouse gas emissions from the agroecosystems. DNDC default parameters for California rice are provided. Where DNDC defaults are not available for the particular rice cultivar in use on a given field, alternative values for defaults prescribed by this protocol may be obtained from the UC Davis Jenkins Lab.[77] The parameters for soil crop simulation are:

- ***Maximum biomass (kg C/ha)*****:** The maximum biomass productions for grain, leaves and 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). If local data are not available, then California default values must be used.
- ***Biomass fraction*****:** The grain, leaves and stem, and root fractions of total rice biomass at maturity.
- ***Biomass C/N ratio*****:** Ratio of C/N for grain, leaves and stem, and roots at maturity.

[76] DNDC allows for data on any soil amendment to be input into the model, and provides default parameters (i.e. C/N ratio) for several types of soil amendments. Users must adopt the DNDC default values for the soil amendments listed, unless no suitable DNDC defaults are provided. Where no DNDC default is provided or alternative values are believed to be more appropriate, users may provide verifiers with sufficient material to justify the use of any such alternative data.
[77] This information can be sourced directly from UC Davis.

- ***Thermal degree days (°C)***: Cumulative air temperature from seeding until rice maturity.
- ***Water demand (g water/g dry matter)***: Amount of water needed for the rice crop to produce a unit of dry matter of biomass (also known as transpiration efficiency).
- ***N fixation index***: The default number is 1 for non-legume crops. For legume crops, the N fixation index is equal to the ratio of total plant N content to plant N taken from soil. For rice, this value must be set at 1.

Default values for N deposition, NH_3 background and CO_2 concentration should be obtained from the National Atmospheric Deposition Program data or data from UC Davis Jenkins Lab.[78] The TDD value will need to be manually input based on a default value found in a look up table derived from UC Davis Jenkins Lab. The remaining soil values will need to be set manually based on DNDC defaults and can be found in the "C:\DNDC\Library\Lib_crop directory." The "crop.lst" file provides the look-up table for crop numbers for each crop. In addition to the crop libraries included with DNDC, the Crop Creator feature (see "Tools" tab on DNDC user interface) allows the user to create a new crop library (by entering in all of the parameters listed above) or modify an existing crop library. Figure C.2, below, shows the DNDC Crop Creator interface. For information on using the Crop Creator, the user may refer to *DNDC User's Guide*, Section III-2.3. The crop creator tool can be used to develop the input parameters for a new rice variety. Where DNDC defaults are not available for the particular rice cultivar in use on a given field, defaults may be obtained from UC Davis Jenkins Lab.

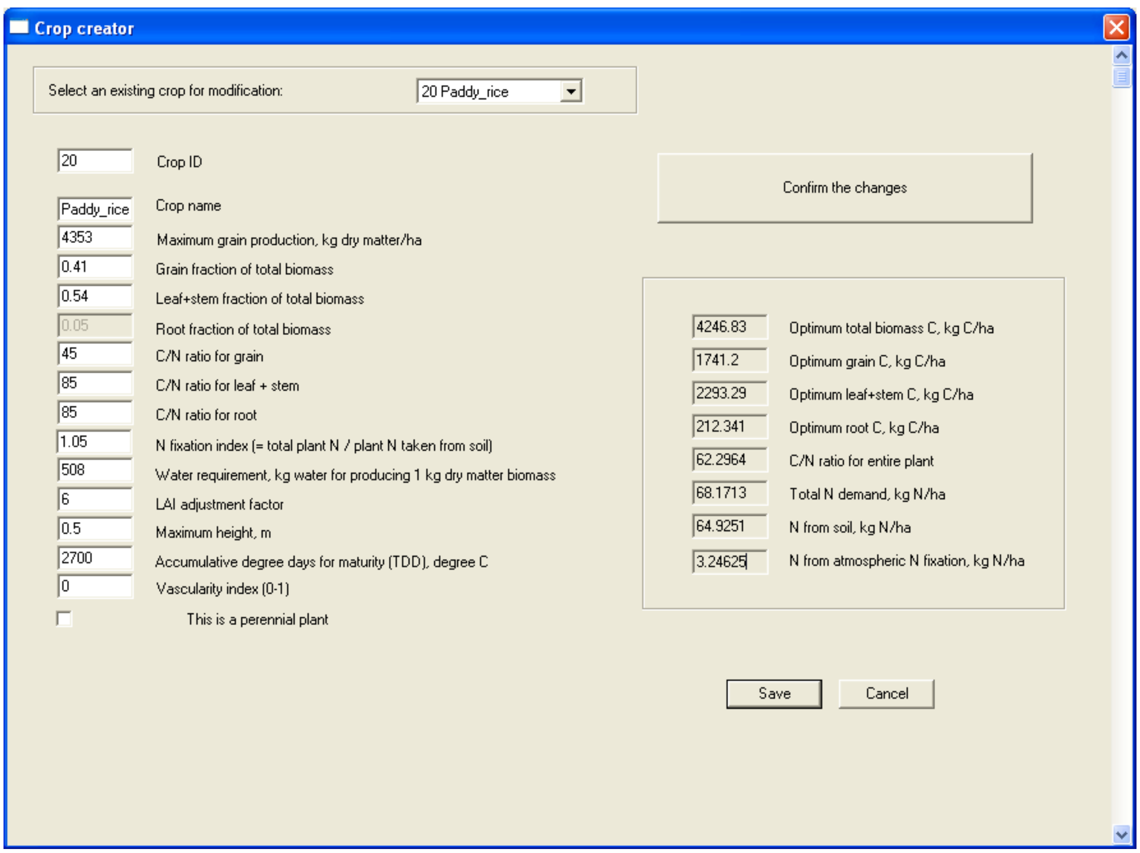

Figure C.2. DNDC Crop Creator

78 This information can be sourced directly from UC Davis. See http://ucanr.edu/sites/UCRiceProject/.

To use the model according to the RCPP, the user must calibrate the DNDC crop model based on actual site conditions. At least five years of observed crop yields should be used for setting maximum rice grain yield (kg C/ha). In addition, for the particular rice variety used, the biomass fraction (% grain and % leaf and stem), and biomass C/N ratio for grain, leaves and stem, and roots should be obtained from the look up tables derived from UC Davis Jenkins lab.[79] DNDC default parameters which can be found in the "C:\DNDC\Library\Lib_crop" directory. DNDC provided default values or defaults sourced from UC Davis must be used for all of these parameters except the maximum biomass parameter, which must be manually set in the model based on historical yields. Biomass fraction and C/N ratios are typically constant for a cultivar, so if no DNDC default value can be found for the particular cultivar used on a given field, an alternative default value can be sourced from UC Davis (see Appendix B Step 1.4 for RCPP requirements). The steps for crop calibration are outlined in Appendix B Step 3.

Running the Model and Viewing Results

Once soil and crop calibration are complete, input parameters are entered, and input files are saved for later use, the model can be run. For details on running the model, the user may refer to the *DNDC User's Guide*, Section III-1.3. Model run results can be viewed either through the DNDC GUI or in text files saved to the user's hard-drive. Results in the DNDC GUI give a quick overview of results by year for crop(s), nitrogen, carbon, water, and greenhouse gas emissions. Viewing results via the GUI is described in detail in the *DNDC User's Guide*, Section III-1.4.

Daily and annual results are saved in text file format so that they can be retrieved and reprocessed with any spreadsheet or word processor tools (e.g. Microsoft Excel or OpenOffice Calc). Daily results include information on crop growth, soil carbon and nitrogen pools and fluxes, soil climate, and water budget. In addition, summarized annual results are saved in report and tabular format. Text file results are described in detail in the *DNDC User's Guide*, Section IV-1.

Greenhouse Gas Emissions Scenarios: Overview

This appendix provides an overview of the GHG emission evaluation process using DNDC. While this document is not intended to be used to select the actual scenarios to be used, we provide some background material here on the general effects of parameter changes in DNDC and a brief discussion of trade-offs between management practices, GHG emission, and crop yield. In addition, we describe the general framework for the ideal approach to scenario evaluation.

General Effects of Model Parameter Changes

The user should consider what GHG mitigation options make sense for their particular application and set-up DNDC modeling appropriately. Seeking input from local experts and surveying literature specific to the system of interest is the preferred approach. This section (and the accompanying tables in the appendix) provides a very general overview of methane mitigation options.

Reductions to CH_4 emissions fall into four categories: changes to soil character, organic matter management, crop/plant management, and flooding. Changes to soil character (such as by converting wetland soils to upland crop) often affect other GHG emissions such as C sequestration or N_2O emissions. Crop or plant management and organic matter management

[79] This information can be sourced directly from UC Davis. See http://ucanr.edu/sites/UCRiceProject/.

are typically effective in wetlands soils. Changes to flooding regime are often the most feasible option, but can also influence N_2O emissions.

Modeling Potential Project Scenarios

Ideally, each scenario should be run for the same time period, using the same site characteristics for several years (five or more): because of climate-related interannual variability, emissions and yields can vary significantly from year to year. Running the model for several years will ensure a reasonable average. If a multi-year run is not possible, a Monte Carlo simulation may provide better results. Due to the use of annual reporting periods, this protocol requires the use of Monte Carlo simulations to reduce model uncertainty.

The general process for evaluating scenarios is as follows (a specific example can be found in the Case Studies section):

- Create baseline input files for DNDC (including *.dnd file and climate files)
- Create management alternatives based on approved project activities
- Run baseline and project management scenarios
- Import text results into spreadsheet software (e.g. Microsoft Excel or OpenOffice Calc) and generate mean annual per hectare values (in CO_2 equivalents) for the principal parameters;
  - Change to soil organic carbon (ΔSOC)
  - Methane (CH_4)
  - Nitrous oxide (N_2O)
- Sum CO_2 equivalents to derive total annual GHG emissions (zeroing out any net emission reductions from SOC or N_2O, as reductions to these gases are not credited in the RCPP)
- Useful graphs might include:
  - Bar chart comparing total GHG emissions by scenario
  - Bar chart comparing grain yield by scenario

Case Study: Paddy Rice

In this section we will provide a step-by-step example of an evaluation of management scenarios for a 20.8 hectare rice paddy in California. In this case, we are using data from an actual field, with six years of detailed management, meteorological and atmospheric, and soils data. Here is the baseline management scenario:

- Single crop: rice
- No removal of crop residue
- Tillage prior to and after cropping
- Fertilizer applications prior to and after planting
- Flooded field from late May through early September
- Winter flood from December through February/March

Entering Input Data

As one would do with any DNDC model site run, we will begin by entering all of the site, soil, and cropping information available to us; this initial set-up will form the basis for the crop calibration process and the baseline run. Figure C.3 shows the basic site information and climate information for our rice paddy. Climate files were created based on data from a nearby agricultural weather station. Nitrogen concentration from rainfall was generated from data from a nearby monitoring station and represents annual average total deposition averaged over the six years.

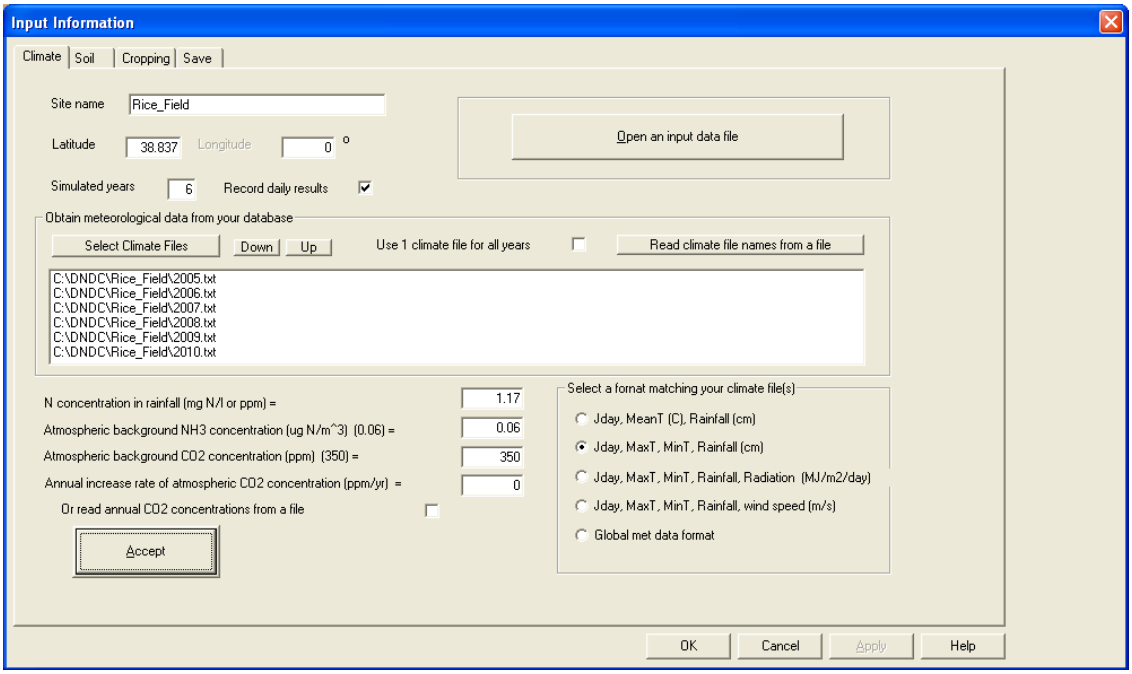

Figure C.3. Rice Site and Climate Input

Figure C.4 shows the soil data for our rice field based on site soil sampling. In this case we have data for the land use type (rice paddy), clay fraction (0.31), bulk density (1.45 g/cm^3), soil pH (7.5), and surface soil organic carbon (0.75 percent). For the rest of the parameters we will use the DNDC defaults.

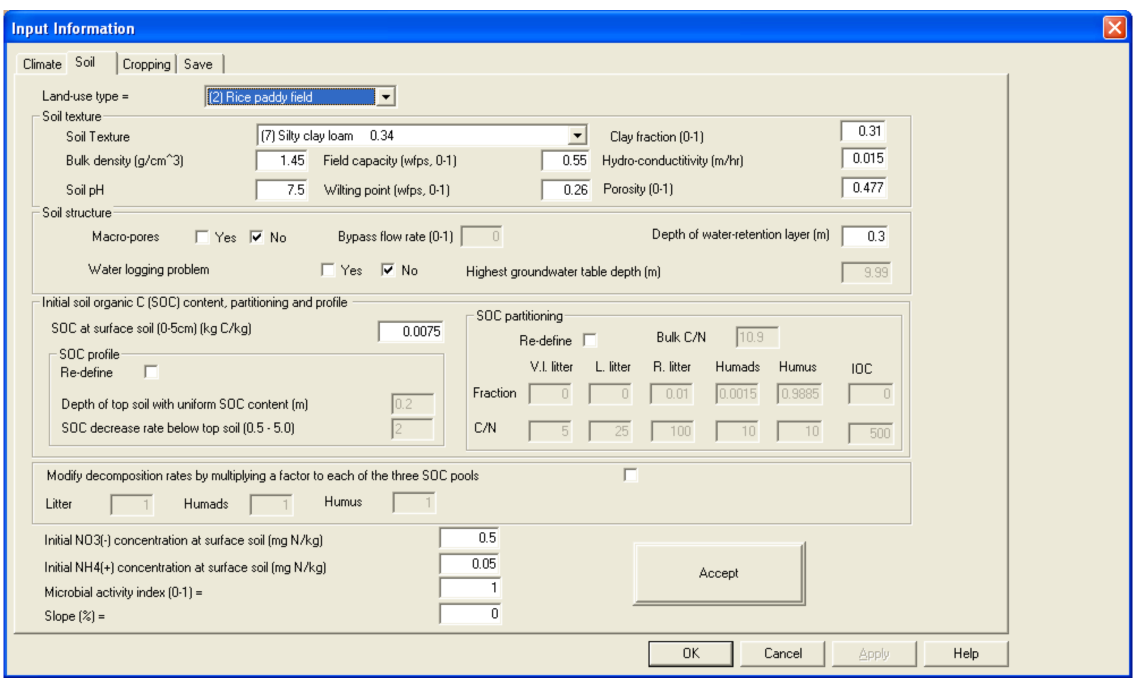

Figure C.4. Rice Soil Input

Next we will setup the cropping systems for our rice paddy. Figure C.5 shows how our cropping systems will be arranged for our six-year time period. The total years of the model run will be six years (based on the input in the Climate/Site tab); since each year of the run will have slightly different parameters, we will set these up as six different cropping systems (i.e. “Number of cropping systems applied…” should be set to 6) each of which lasts one year (i.e. “Duration of this cropping system…” should be set to 1 for each year).

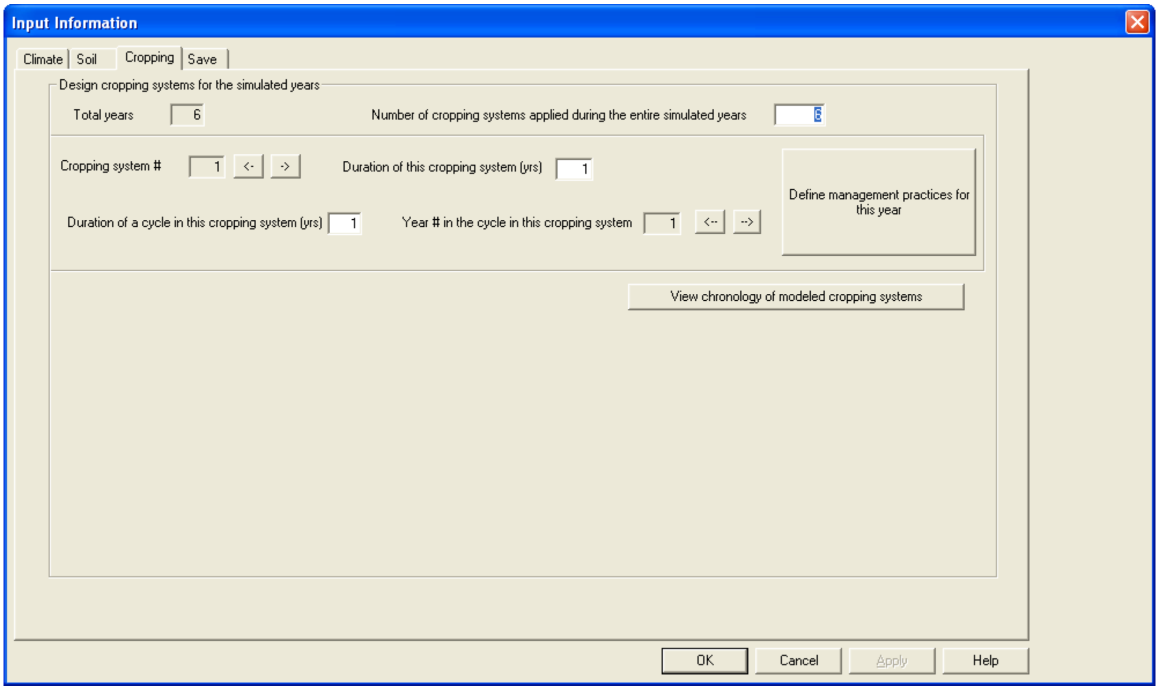

Figure C.5. Rice Cropping Systems

For this demonstration, we will show a single cropping system (year 1) as entered into DNDC (Figure C.6 through Figure C.8). The user can enter the cropping information for years 2 through 6 based on the information shown in Table C.3.

Table C.3. Rice Cropping System Information

Year	2005	2006	2007	2008	2009	2010
Cropping System	**1**	**2**	**3**	**4**	**5**	**6**
Plant Date	5/19	6/1	5/22	5/22	5/21	5/30
Harvest Date	10/12	10/30	10/15	10/13	10/29	11/12
Tillage 1	5/12 – 10 cm	5/25 – 10 cm	5/15 – 10 cm	5/15 – 10 cm	5/14 – 10 cm	5/23 – 10 cm
Tillage 2	5/13 – 10 cm	5/26 – 10 cm	5/16 – 10 cm	5/16 – 10 cm	5/15 – 10 cm	5/24 – 10 cm
Tillage 3	5/14 – 0 cm	5/27 – 0 cm	5/17 – 0 cm	5/17 – 0 cm	5/16 – 0 cm	5/25 – 0 cm
Tillage 4	10/18 – 5 cm	11/5 – 5 cm	10/21 – 5 cm	10/19 – 5 cm	11/4 – 5 cm	11/18 – 5 cm
Tillage 5	10/19 – 5 cm	11/6 – 5 cm	10/22 – 5 cm	10/20 – 5 cm	11/5 – 5 cm	11/19 – 5 cm
Fertilization 1	5/14 - 114.33 kg N/ha Urea	5/27 - 112.09 kg N/ha Urea	5/17 - 116.57 kg N/ha Urea	5/17 - 121.05 kg N/ha Urea	5/16 - 134.5 kg N/ha Urea	5/25 - 146.83 kg N/ha Urea
	injected to 10 cm	injected to 10 cm	injected to 10 cm	injected to 10 cm	injected to 10 cm	injected to 10 cm
Fertilization 2	6/29 – 168.13 kg N/ha Ammonium Sulfate	7/13 - 168.13 kg N/ha Ammonium Sulfate	7/25 - 168.13 kg N/ha Ammonium Sulfate	-	6/25 - 168.13 kg N/ha Ammonium Sulfate	7/4 – 196.15 kg N/ha Ammonium Sulfate
	applied to surface	applied to surface	applied to surface	-	applied to surface	applied to surface
Fertilization 3	-	-	-	-	7/10 – 196.15 kg N/ha Ammonium Sulfate	7/17 – 168.13 kg N/ha Ammonium Sulfate
	-	-	-	-	applied to surface	applied to surface
Flood Date	5/15/2005	5/27/2006	5/17/2007	6/11/2008	6/20/2009	5/24/2010
Drain Date	9/8/2005	9/24/2006	9/15/2007	9/10/2008	9/22/2009	10/2/2011
Additional Info				two "flushes" this year, entered as single day floods on 5/17 and 6/2	two "flushes" this year, entered as single day floods on 5/23 and 6/7	
Winter Flood Date	12/1/2005	12/1/2006	12/1/2007	12/1/2008	12/1/2009	12/1/2010
Winter Drain Date	2/28/2006	2/28/2007	2/28/2008	2/28/2009	3/15/2010	3/15/2011
Leak Rate	0.08	0.08	0.08	0.08	0.08	0.08
Yield (kg/ha)	9,796	9,097	10,882	8,980	10,087	7,220
Yield (kg C / ha)	3,918	3,639	4,353	3,592	4,035	2,888

Figure C.6 shows crop information for year 1. In this case we have entered crop type (paddy rice), planting dates, and fraction of leaves and stems left in the field (assumed to be all of the crop residue or 100 percent). In addition, in preparation for the crop calibration process we have entered in the maximum biomass for grain based on our measured data (4,353 kg C/ha) and the biomass C/N ratio from field measured data – we have accepted the default values for the rest of the crop parameters for now.

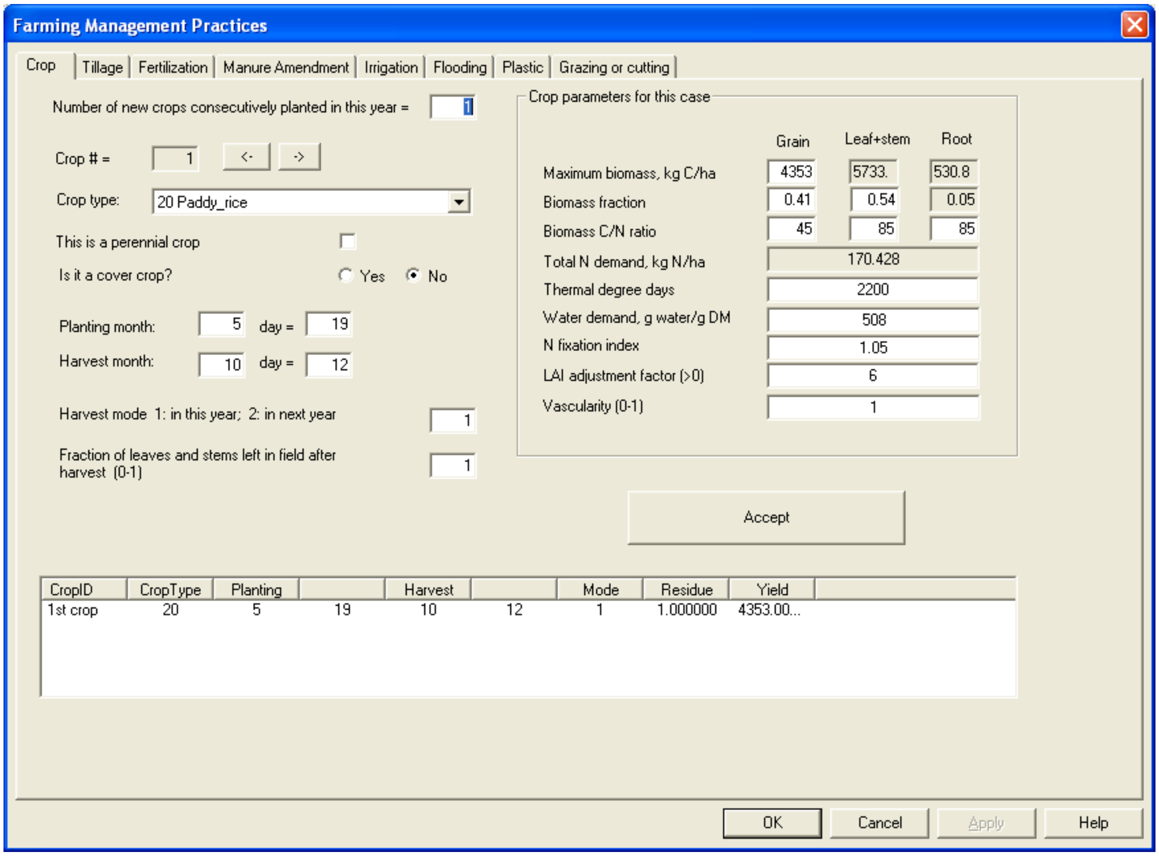

Figure C.6. Rice Farming Management Practices – Crop

Figure C.7 shows tillage practices. We have entered in all five applications and their associated dates and methods.

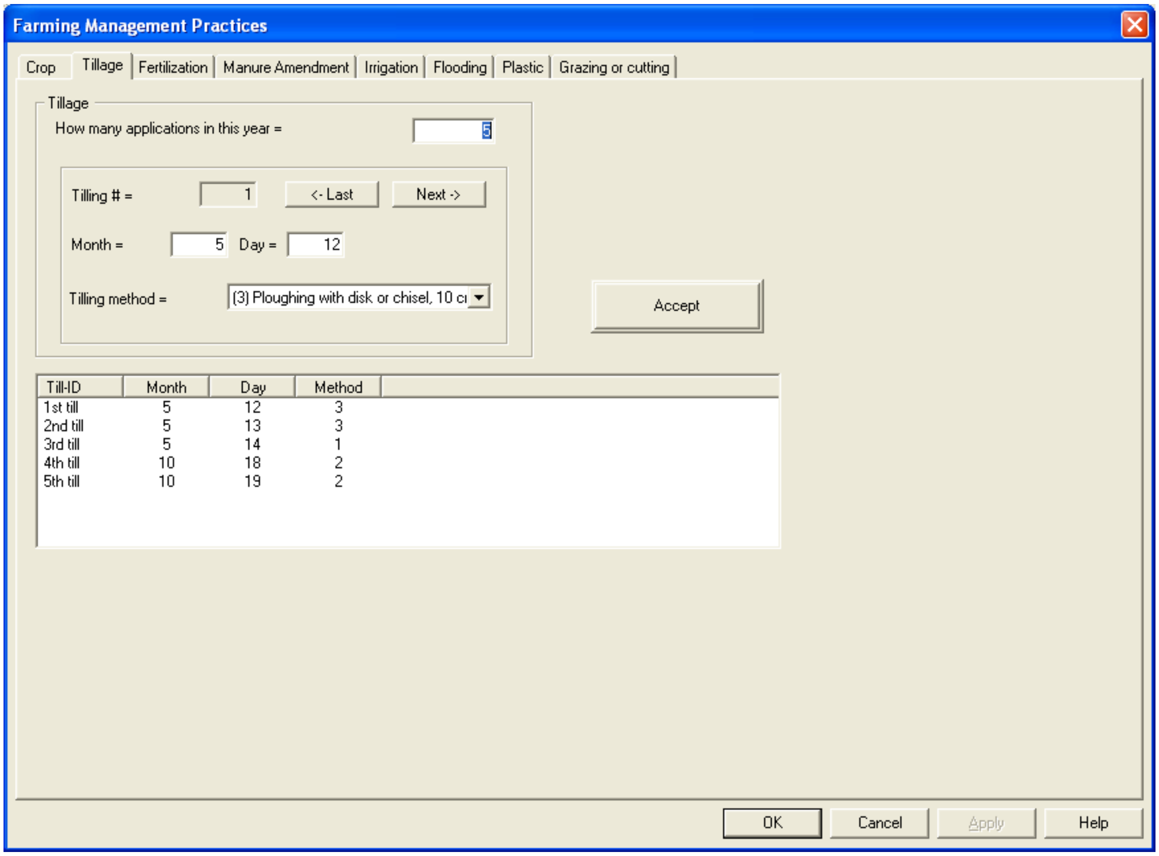

Figure C.7. Rice Farming Management Practices – Tillage

Figure C.8 shows fertilizer applications. We have entered in two applications and their associated dates, depths, and amounts.

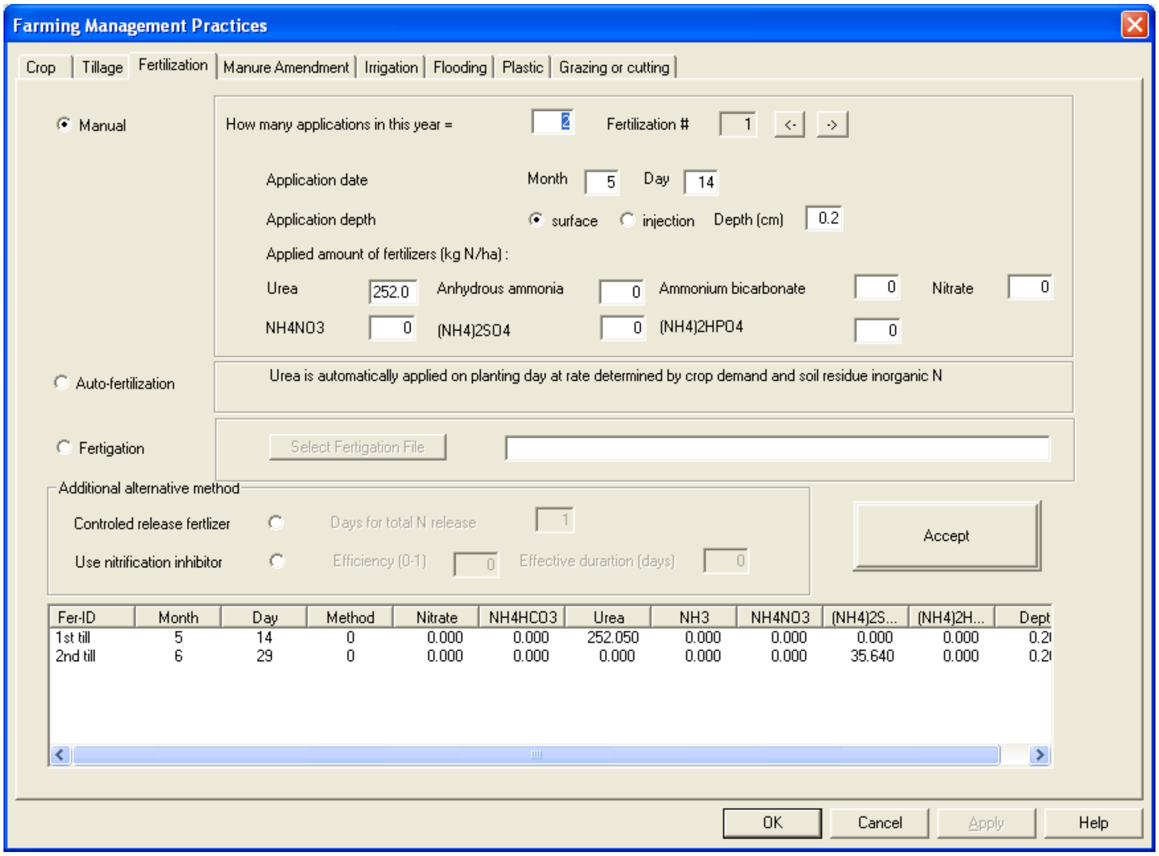

Figure C.8. Rice Farming Management Practices – Fertilization

Figure C.9 shows flooding management. We have entered in two floods (one seasonal and one winter flood) and their associated start and end dates as well as a leak rate of 0.08.

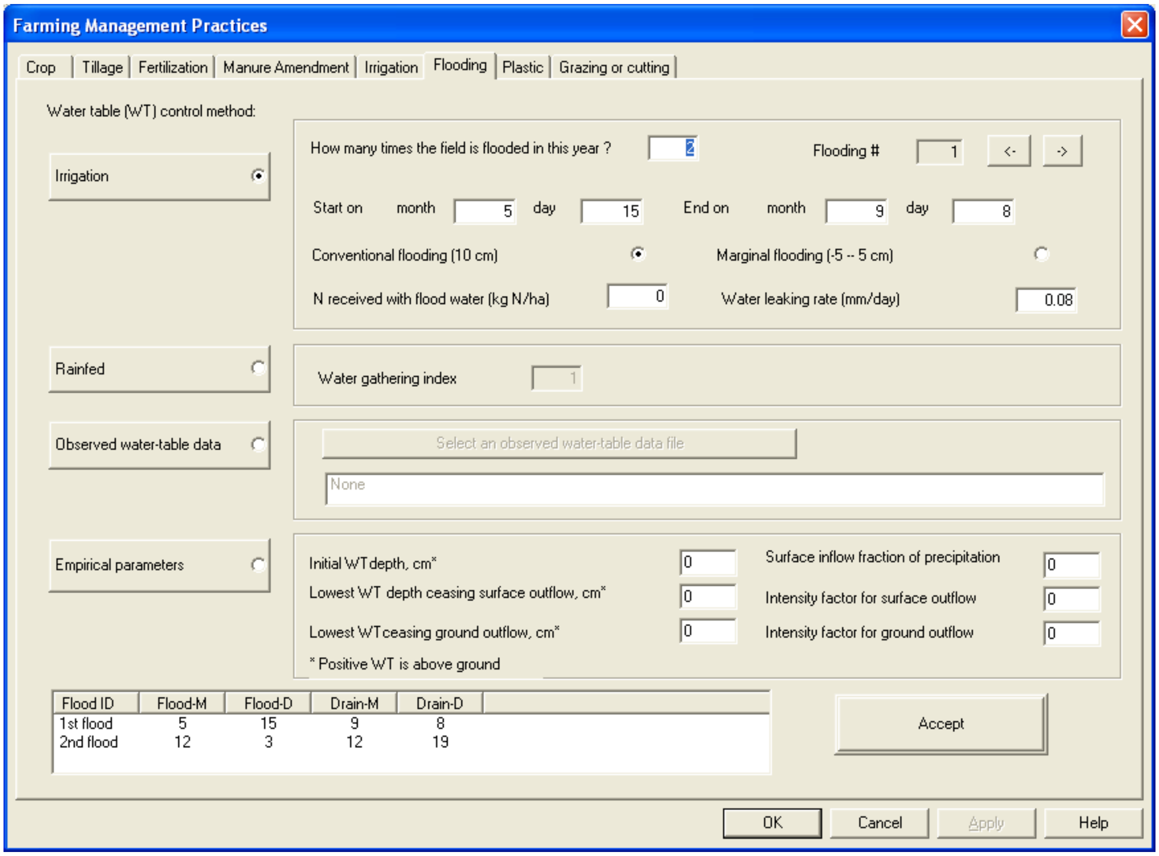

Figure C.9. Rice Farming Management Practices – Flooding

Since the farming management practices for this particular paddy do not involve any manure amendments, irrigation, plastic applications, or grazing/cutting, we will not enter any information on these tabs. The user should ensure that no residual information remains on these tabs from previous model runs.

When all of the information is entered, the user should save the results to a *.dnd file – we will call this “Baseline.dnd”; this file can be used later to set-up alternative management scenarios or to re-run model results.

Crop Model Calibration

The model can now be run to prepare for the crop model calibration – this can be done on the main DNDC screen by clicking the site mode “Run” button. Results are put in the “C:\DNDC\Result\Record\Site” directory.

To review the first iteration of the crop calibration process, we need to compare the modeled yield with measured yield. Modeled yield can be found in “Multi_year_summary.csv” in the “Yield_GrainC” field. These values can be compared with measured yields as in Table C.4. In this case, the maximum absolute difference between measured and modeled yields is large (48 percent) so we will opt to run another iteration with adjusted crop parameters.

Table C.4. Rice Crop Model Calibration – Iteration 1

Year	DNDC Yield (Yield_GrainC)	Measured Yield	Absolute Difference	Absolute Difference Percent
1	4,041	3,918	123	3%
2	4,012	3,639	373	10%
3	4,134	4,353	219	5%
4	3,266	3,592	326	9%
5	3,506	4,035	529	13%
6	4,266	2,888	1,378	48%

We will start the calibration process by modeling a single year: the year with the maximum measured yield (year 3). We will create the run using all of the site characteristics (climate, soil, and known crop parameters), and, as suggested in step 1 of the calibration process, we will use optimal fertilization (i.e. use the auto-fertilization setting). When this iteration is run, grain yield is 4,264 kg C/ha/y; a difference of only two percent. Since this difference is small, we will use the maximum measured yield as the maximum biomass parameter.

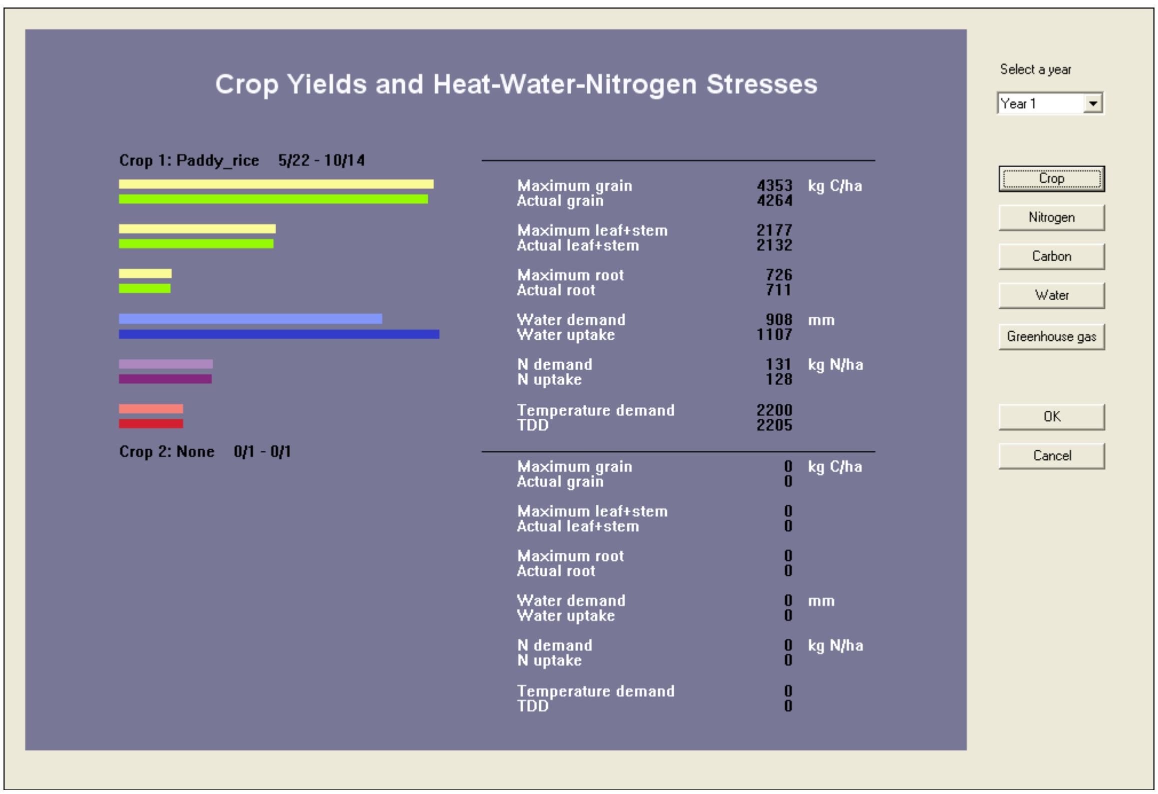

Figure C.10. Rice Crop Yields - Iteration 1

Next, we will check the modeled grain maturity date in the “Day_FieldCrop.csv” file: grain matures on day 238 (August 26) – this appears to be too early as the maturity date should be approximately the same date as the seasonal flood drain date (September 15). By increasing the thermal degree days parameter from 2,200 to 2,700 and re-running the model, we arrive at a more reasonable maturity date (day 260 or September 17).

Since there is no irrigation for paddy rice crops we can skip step 3 of the calibration process. We can now make one minor adjustment to the baseline scenario based on the calibration process: change the crop thermal degree days parameter from 2,200 to 2,700.

Creating Alternative Management Scenarios

For this rice paddy example we will look at two scenarios:

- Water seeded rice with all crop residue left onsite, with a winter flood (the baseline scenario)
- Dry seeded rice with all crop residue left onsite, with a winter flood (the dry seeded scenario)

To do this, we will make a copy of the baseline scenario ("Baseline.dnd") to be adjusted for the alternative scenarios. Each file can be renamed to represent a scenario. We will use the following file names:

- "Baseline.dnd"
- "DrySeeded.dnd"

There are two ways to change the parameters in each *.dnd file. The first is through the DNDC GUI. For a complicated, multi-year run, this is straightforward and a less error-prone method. Users who familiarize themselves with the *.dnd file format (see *DNDC User's Guide*, Section III-1.2) may be able to make these same changes in a text editor.

We will go through the revision process for the above-listed scenarios here ("DrySeeded.dnd").

Here are the key changes to the baseline to create the dry seeded scenario:

- Site name ⟶ dry seeded[80]
- Adjust the timing of the flood-up period relative to seeding, shift from May 17 to June 12
- Add two irrigation events (May 23 and June 1)

Open the "DrySeeded.dnd" scenario on the DNDC Input Information dialogue (click on "Open an input data file"). The site name can be changed on the Climate tab of the Input Information dialogue. We will call this scenario "DrySeeded."

For each of the cropping systems (years), we will change the flooding information. Baseline flooding is shown in Figure C.11. And, since we are shifting to dry seeding, we will shift the second flood start date from May 17 to June 12 (see Figure C.12).

[80] Project developers will eventually be running these scenarios in batch mode, so it is important that the site name be changed so that project developers will be able to distinguish the various results from each other.

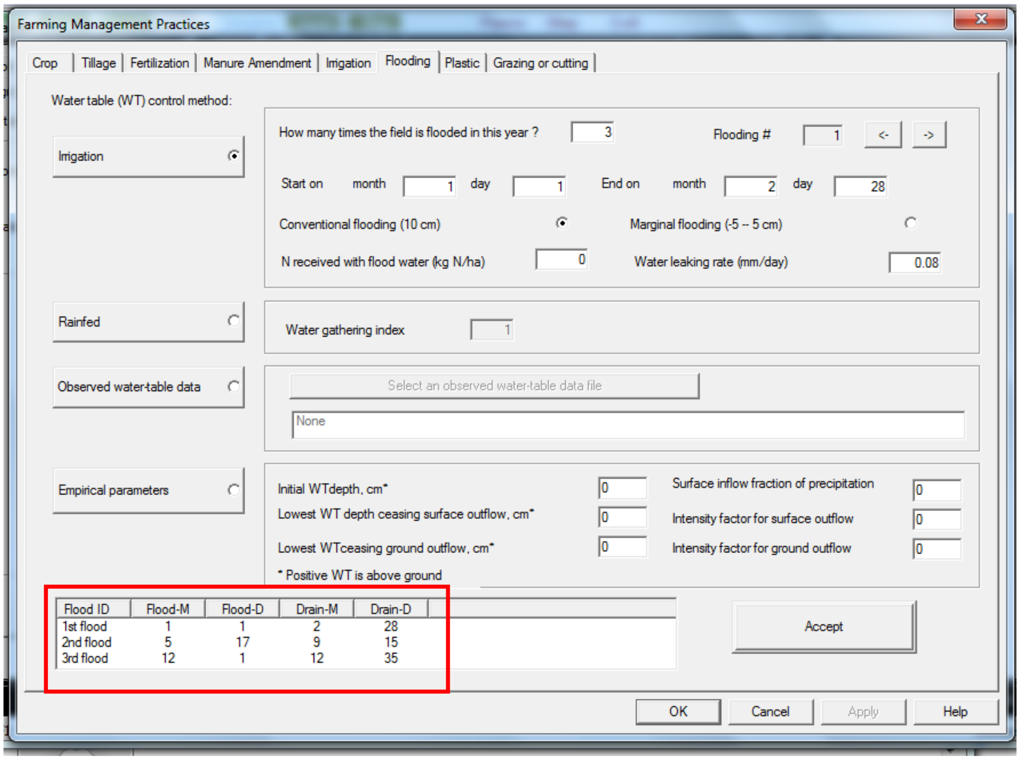

Figure C.11. Baseline to Flooding

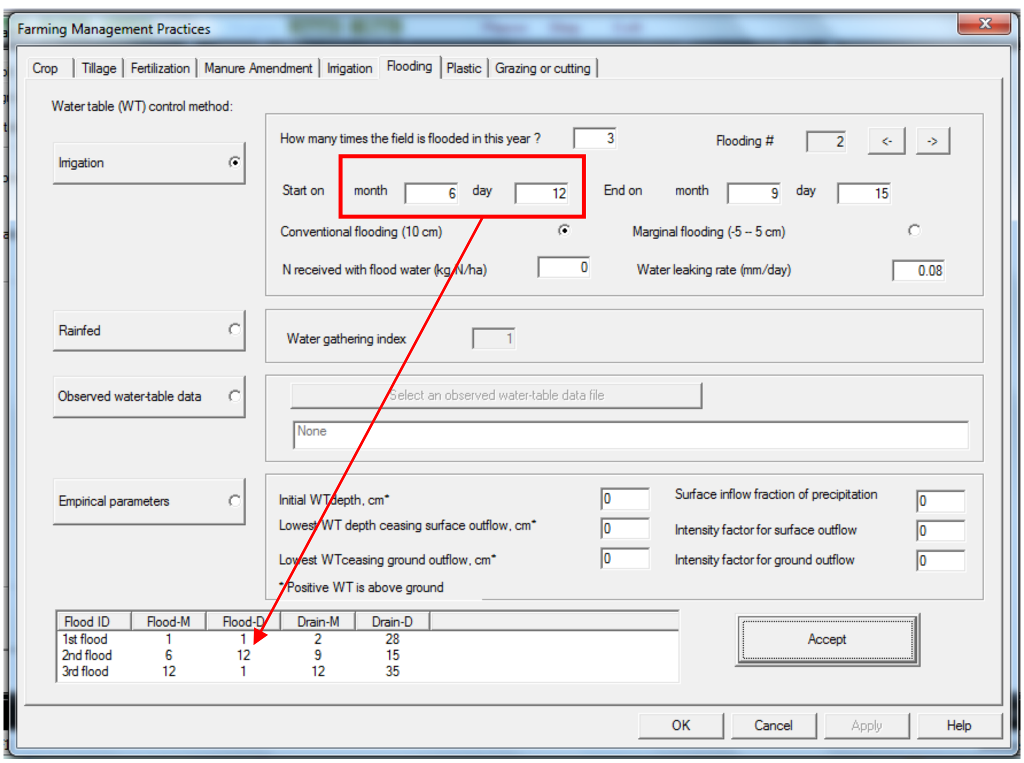

Figure C.12. Dry Seeding Flooding

In addition to a shift in when the fields are flooding for the rice growing season, dry seeding requires irrigation events following seeding to establish a good crop canopy prior to flooding. For this example we illustrate use of two irrigation events (May 23 and June 1) with 10 cm irrigation water for each event. Figure C.13 illustrates the DNDC irrigation tab with these two 10 cm irrigation events scheduled for May 23 and June 1.

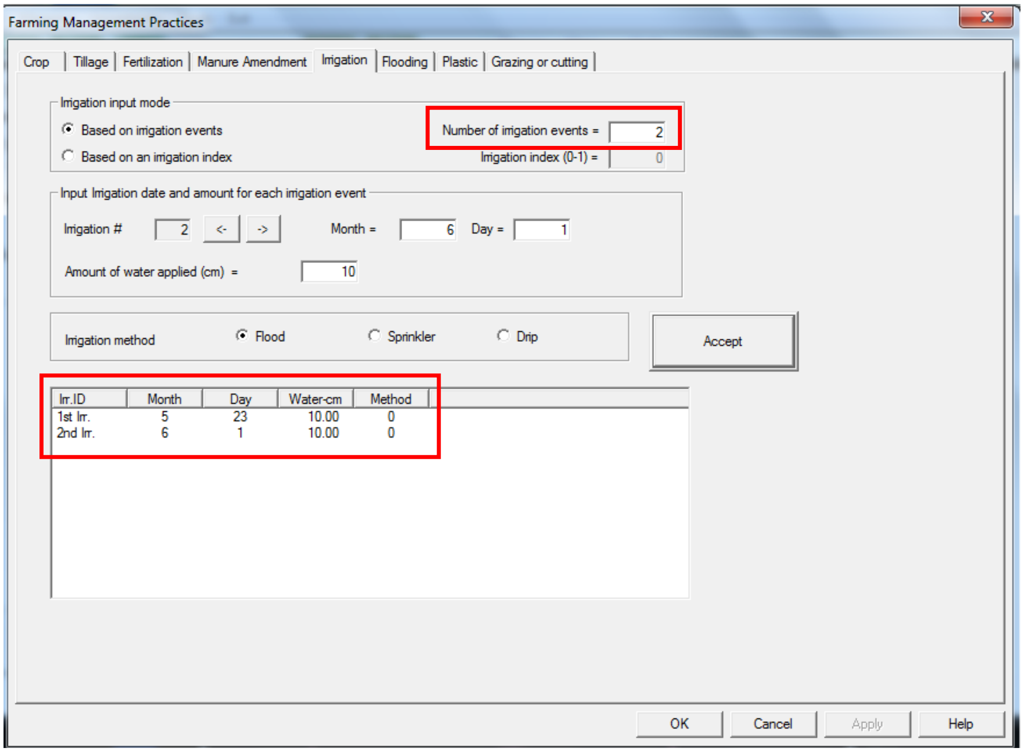

Figure C.13. Irrigation Events for Dry Seeding Scenario

Results for each site run can be examined using the DNDC results tab. Annual emissions for year 20 of a 20-year run for both baseline and dry seeded scenarios are presented in Figure C.14 and Figure C.15, respectively.

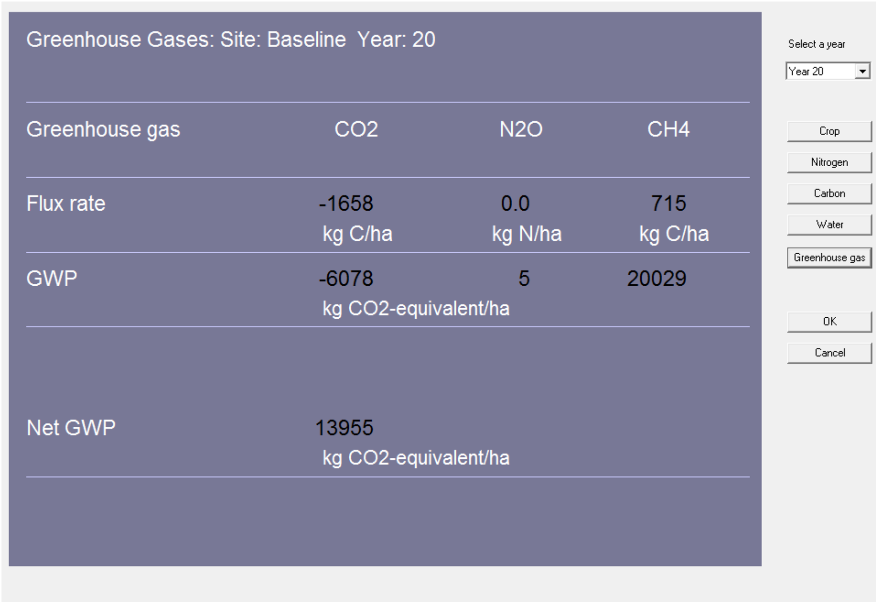

Figure C.14. DNDC Results Panel for Baseline Scenario

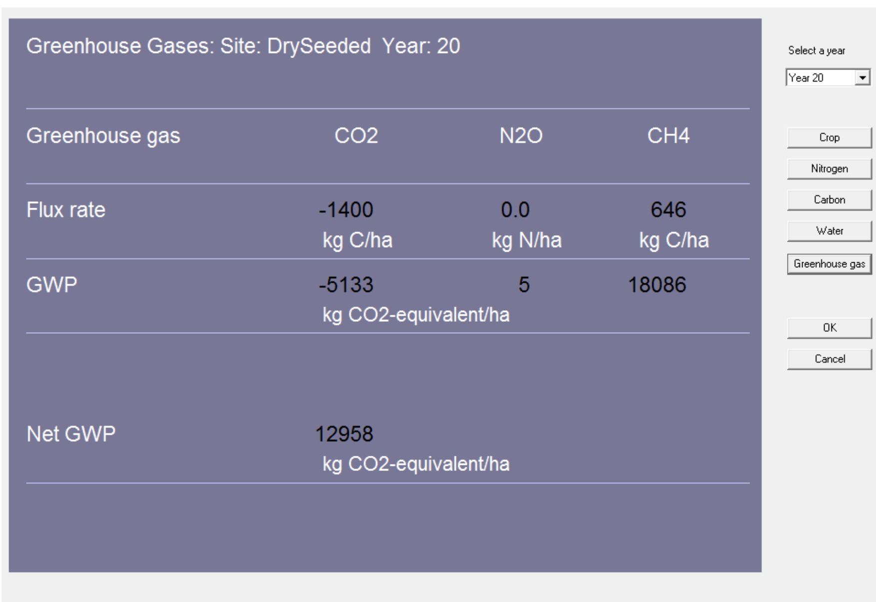

Figure C.15. DNDC Results Panel Dry Seeding Scenario

For this example shift from wet seeded rice to dry seeded, the modeled reduction in GHG emissions was 0.997 tCO_2e/ha.

Once the site level *.dnd files are created for both the baseline and project scenarios, the new software tool for creating all the batch file inputs following the Monte Carlo sampling procedures described in the RCPP can be run. Once the input files are complete, the user can then select batch mode from the tools menu in DNDC (see Figure C.16) and run DNDC in batch mode. A second software tool will then compile all the results from the batch run and provide the model estimates of GHG reductions.

Figure C.16. Batch Mode in DNDC

Appendix D Derivation of Structural Uncertainty Deduction Factors

D.1 Overview

As described in Section 5.4.2 of the protocol, the deduction factor to account for DNDC model structural uncertainty will be published on the Reserve's website (and periodically updated),. This section explains the methodology used by the Reserve to determine the deduction factor.

The structural uncertainty deduction factor will be a function of the total number of fields registering emission reductions with the Reserve in any given cultivation cycle. The procedure described in this appendix will be performed for each region for which the RCPP is applicable in order to determine the appropriate uncertainty deduction factor to be used for each region. For each region, the Reserve will determine the exact deduction factors to be used, and whether the deduction factors are additive or multiplicative (determined as described below). This version of the protocol is applicable to the California Sacramento Valley Region and uses DNDC Version 9.5, for which the structural uncertainty deduction is additive. The structural uncertainty factor is derived based on validation of a specific version of DNDC, and can only be applied to that version. As such, the Reserve will publish structural uncertainty deductions that are specific to a single version of the DNDC model.

The structural uncertainty deduction factor $\boldsymbol{\mu_{struct}}$ is defined such that, after application of the uncertainty deduction factor to the direct emission reductions[81] the following inequality holds in 95 percent of the cases, i.e. with 95 percent confidence.

$$\mathbf{DERs} < \boldsymbol{BE_{meas}} - \boldsymbol{PE_{meas}}$$

The uncertainty deduction can be either added or multiplied to the gross difference between project and baseline emissions, depending on whether the error structure of the residuals is additive or multiplicative.

In the additive case:

$$\mathbf{DERs} = \boldsymbol{\mu_{struct}} + (\boldsymbol{BE_{meas}} - \boldsymbol{PE_{meas}})$$

In the multiplicative case:

$$\mathbf{DERs} = \boldsymbol{\mu_{struct}} \times (\boldsymbol{BE_{meas}} - \boldsymbol{PE_{meas}})$$

Where,

DERs	=	Direct emission reductions
μ_{struct}	=	Structural uncertainty factor
$PE_{meas}(i)$	=	Field results for project emissions
$BE_{meas}(i)$	=	Field results for baseline emissions

Before the derivation of $\boldsymbol{\mu_{struct}}$ is continued, the lack of bias is confirmed and it is determined whether the error structure of the residuals is additive or multiplicative.

[81] Note that although DNDC is used to model both direct emission reductions and some indirect emission reductions, for simplicity, this guide refers to all modeled emission reductions as direct.

D.2 Confirming the Lack of Bias

The derivation of the structural uncertainty term assumes that no bias exists between measured and modeled results, or that $\langle \boldsymbol{Y_{meas}} \rangle = \langle \boldsymbol{Y_{model}} \rangle$. 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. For each region, it is explicitly tested that the model calibration strategy does not lead to bias by comparing modeled and measured emissions using a paired t-test.

D.3 Verification of the Nature of the Structural Error

The structural error induced by a biogeochemical model such as DNDC is either multiplicative or additional.

In case the error is additive:

$$\boldsymbol{Y_{model,i} = Y_{field,i} + \varepsilon_i} \text{ with } \boldsymbol{\varepsilon \sim \mathcal{N}(0, \sigma)}$$

In case the error is multiplicative:

$$\boldsymbol{Y_{model,i} = Y_{meas,i} \times e^{\varepsilon_i}} \text{ with } \boldsymbol{\varepsilon \sim \mathcal{N}(0, \sigma)}$$

For each region, it is explicitly determined whether an additive or multiplicative error model must be assumed. The deviation between modeled and measured results will be multiplicative if residuals increase with increasing modeled values. However, if the deviation between modeled and measured results is additive, the residuals will be constant across modeled values. This is verified by investigating the heteroscedasticity of the residuals or by plotting the residuals versus the model values. In case of doubt, the additive case will lead to more conservative crediting than the multiplicative case and may be used as a default.

D.4 Derivation of the Structural Uncertainty Deduction in Case the Error Term is Additive

If the error is additive and the model is bias-free, the following error model can be assumed for the project and baseline emissions.

$$\boldsymbol{PE_{model} = PE_{meas} + \varepsilon_1} \text{ with } \boldsymbol{\varepsilon_1 \sim \mathcal{N}(0, \sigma^2)}$$
$$\boldsymbol{BE_{model} = BE_{meas} + \varepsilon_2} \text{ with } \boldsymbol{\varepsilon_2 \sim \mathcal{N}(0, \sigma^2)}$$

A correlation between the project and baseline residuals may exist:

$$\boldsymbol{\rho} = \textbf{corr}(\boldsymbol{\varepsilon_1}, \boldsymbol{\varepsilon_2})$$

Where,

μ_{struct}	=	Structural uncertainty factor
$PE_{model}(i)$	=	Model results for project emissions
$BE_{model}(i)$	=	Model results for baseline emissions
$PE_{meas}(i)$	=	Field results for project emissions
$BE_{meas}(i)$	=	Field results for baseline emissions
ε_1	=	Error term for project emissions

ε_2	=	Error term for baseline emissions
σ	=	Standard deviation of the residuals between modeled and measured values
ρ	=	Correlation between project residuals and baseline residuals

If the direct emission reductions are the difference between project and baseline, one can write:

$$\boldsymbol{DER_{model} = BE_{model} - PE_{model}}$$
$$\boldsymbol{DER_{meas} = BE_{meas} - PE_{meas}}$$

Where:

DER_{model}	=	Direct emission reductions based on modeled emissions
DER_{meas}	=	Direct emission reductions based on measured emissions

Because there is no bias between the model and the measurements, the average of the difference between $DER_{model} - DER_{meas}$ is 0. The variance of this difference is:

$$\begin{aligned} \mathbf{Var}(\boldsymbol{DER_{model} - DER_{meas}}) &= \mathbf{Var}(\boldsymbol{\varepsilon_1}) + \mathbf{Var}(\boldsymbol{\varepsilon_2}) - \mathbf{2Cov}(\boldsymbol{\varepsilon_1}, \boldsymbol{\varepsilon_2}) \\ &= \boldsymbol{\sigma^2 + \sigma^2 - 2\sigma^2\rho} \\ &= \boldsymbol{2\sigma^2(1-\rho)} \end{aligned}$$

In case there are multiple fields **n**, the inequality introduced in the beginning of this section has to hold only for the sum of the direct emission reductions, and for the direct emission reductions of each individual field. In this case, the variance of the sum of the emission reductions is:

$$\begin{aligned} \mathbf{Var}\left(\sum_{i=1}^{n} \boldsymbol{DER_{model,i} - DER_{meas,i}}\right) &= \boldsymbol{n}\cdot\mathbf{Var}(\boldsymbol{\varepsilon_1}) + \boldsymbol{n}\cdot\mathbf{Var}(\boldsymbol{\varepsilon_2}) - \boldsymbol{2n}\cdot\mathbf{Cov}(\boldsymbol{\varepsilon_1}, \boldsymbol{\varepsilon_2}) \\ &= \boldsymbol{n\sigma^2 + n\sigma^2 - 2n\sigma^2\rho} \\ &= \boldsymbol{2n\sigma^2(1-\rho)} \end{aligned}$$

If s is the standard deviation of the model residuals based on a limited set of k calibration values, the one-sided 95 percent confidence interval around the sum of the differences $DER_{model} - DER_{meas}$ is:

$$\boldsymbol{DER_{model} - DER_{meas}} < s\sqrt{\boldsymbol{2(1-\rho)}} \times \boldsymbol{t_{inv}(0.95, k)}$$

In other words:

$$\boldsymbol{\mu_{struct}} = \frac{\boldsymbol{s\sqrt{2(1-\rho)}}}{\boldsymbol{\sqrt{n}}} \times \boldsymbol{t_{inv}(0.95, k)}$$

Where:

μ_{struct}	=	Structural uncertainty factor
s	=	Standard deviation
ρ	=	Correlation between project residuals and baseline residuals
t_{inv}	=	Inverse of the cumulative t-distribution with a specific confidence and degrees of freedom
k	=	Number of pairs of modeled and measured values used for model verification.
n	=	Number of fields within the project “aggregate”

D.5 Derivation of the Structural Uncertainty Deduction in Case the Error Term is Multiplicative

If the error is multiplicative and the model is bias-free, the following error model can be assumed for the project and baseline emissions:

$\boldsymbol{PE_{model}} = \boldsymbol{PE_{meas}} \times \boldsymbol{e^{\varepsilon_1}}$ with $\boldsymbol{\varepsilon_1 \sim \mathcal{N}(0, \sigma^2)}$
$\boldsymbol{BE_{model}} = \boldsymbol{BE_{meas}} \times \boldsymbol{e^{\varepsilon_2}}$ with $\boldsymbol{\varepsilon_2 \sim \mathcal{N}(0, \sigma^2)}$

A correlation between the project and baseline residuals may exist:

$\boldsymbol{\rho} = \mathbf{corr}(\boldsymbol{\varepsilon_1}, \boldsymbol{\varepsilon_2})$

Where:

$\mathrm{PE_{model}(i)}$	=	Model results for project emissions
$\mathrm{BE_{model}(i)}$	=	Model results for baseline emissions
$\mathrm{PE_{meas}(i)}$	=	Field results for project emissions
$\mathrm{BE_{meas}(i)}$	=	Field results for baseline emissions
ε_1	=	Error term for project emissions
ε_2	=	Error term for baseline emissions
σ	=	Standard deviation of the residuals between modeled and measured values
ρ	=	Correlation between project residuals and baseline residuals

We will use the same terminology DER_{model} and DER_{meas} as introduced in the additive case in the subsequent derivation. The derivation is similar to the additive case if the following log-transformation is applied:

$$\ln\left(\frac{DER_{meas}}{DER_{model}}\right) = \ln(PE_{meas}) + \varepsilon_1 - \ln(BE_{meas}) - \varepsilon_2 - \ln(PE_{meas}) + \ln\,(BE_{meas})$$

The variance of this ratio can be derived similarly as for the additive case:

$$\mathbf{Var}\left(\ln\left(\frac{DER_{meas}}{DER_{model}}\right)\right) = 2\sigma^2(1-\rho)$$

The quantity **σ** can be estimated by the standard deviation of the difference of the log-transformed project and baseline emissions based on a limited set of **k** calibration values on the condition that a student-t distribution is used in the subsequent one-sided confidence interval:

$$\sum_{i=1}^{n} \ln\left(\frac{DER_{meas}}{DER_{model}}\right) < s\,\frac{\sqrt{2(1-\rho)}}{\sqrt{n}} \times t_{inv}(0.95, k)$$

Rearranging this equation yields:

$$\ln\left(\frac{DER_{meas}}{DER_{model}}\right) < s\,\frac{\sqrt{2(1-\rho)}}{\sqrt{n}} \times t_{inv}(0.95, k)$$

$$\boldsymbol{DER_{meas}} < DE\boldsymbol{R_{model}} \times \boldsymbol{e}^{\boldsymbol{s}\frac{\sqrt{2(1-\rho)}}{\sqrt{n}}\times \boldsymbol{t_{inv}}(0.95,\boldsymbol{k})}$$

In other words:

$$\boldsymbol{\mu_{struct}} = \boldsymbol{e}^{-\boldsymbol{s}\frac{\sqrt{2(1-\rho)}}{\sqrt{n}}\times \boldsymbol{t_{inv}}(0.95,\boldsymbol{k})}$$

D.6 Quantifying the Standard Deviation s and the Correlation ρ

The calculation of $\boldsymbol{\mu_{struct}}$ is critically dependent on the standard deviation of the residuals (i.e. the difference between modeled and measured values) **s** and the correlation between the residuals of the project emissions and the residuals of the baseline emissions **ρ**.

These quantities are calculated based on at least 8 pairs of measured and simulated annual emissions that have been measured over at least two growing seasons.

In case only annual fluxes are available, $\boldsymbol{k}$ pairs of $(\boldsymbol{Y_{meas}(i), Y_{model}(i)})$ will be available with $\boldsymbol{k \geq 8}$.

In the additive error case, the quantity $\boldsymbol{s}$ can be calculated as the standard deviation of the difference between $\boldsymbol{Y_{meas}(i)}$ and $\boldsymbol{Y_{model}(i)}$. Note that the student-t distribution includes a deduction due to the standard deviation being estimated on a limited set of values. Lower deductions will be achieved if k is higher and more measurements are available.

The quantity ρ can be estimated by dividing the measurements in "baseline" cases, $\boldsymbol{BE_{meas}(i)}$ and "project" cases, $\boldsymbol{PE_{meas}(i)}$. In conventional language, the baseline would be the control or conventional treatment. Subsequently, pairs of measured and simulated emission reductions $\boldsymbol{DER_{meas}(i)}$ and $\boldsymbol{DER_{model}(i)}$ can be calculated as the difference between $\boldsymbol{PE_{meas}(i)}$ and $\boldsymbol{BE_{meas}(i)}$, and $\boldsymbol{PE_{model}(i)}$ and $\boldsymbol{BE_{model}(i)}$, respectively. **ρ** is calculated as the correlation coefficient between $\boldsymbol{DER_{meas}(i)}$ and $\boldsymbol{DER_{model}(i)}$. Smaller correlation coefficients will result in greater uncertainty deductions. Therefore, a set of correlation coefficients is calculated through leave-one-out jackknifing and the correlation coefficient set to the low range of this set of values.

In the multiplicative error case, the quantity s can be calculated as the standard deviation of the difference between $\boldsymbol{\ln Y_{meas}(i)}$ and $\boldsymbol{\ln Y_{meas}(i)}$. Similarly as for the additive case, smaller deductions will be achieved if $\boldsymbol{k}$ is higher and more measurements are available. **ρ** is calculated as the correlation coefficient between $\boldsymbol{\ln\left(\frac{PE_{meas}(i)}{BE_{meas}(i)}\right)}$ and $\boldsymbol{\ln\left(\frac{PE_{model}(i)}{BE_{model}(i)}\right)}$.

However, if a set of daily fluxes are available, the quantities $\boldsymbol{s}$ and **ρ** are calculated with more accuracy based on daily values of these quantities as:

$$\boldsymbol{s_{annual}} = \boldsymbol{365} \times \boldsymbol{s_{daily}}$$
$$\boldsymbol{\rho_{annual}} = \boldsymbol{\rho_{daily}}$$

Note that any other time period (i.e. 3-daily or weekly) can be used.

Appendix E 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.

E.1 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, and (5) reduction in seedling loss due to salt.

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 to 30 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 percent of the acreage in California. Fields are flooded to a depth of 4 to 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 for draining the fields can vary and can influence total yields.

The University of California Cooperative Extension (UCCE) recommends that growers drain their fields when the panicles are "fully tipped and golden." This is done through visual inspection and is typically two to four weeks prior to anticipated harvest date. According to UCCE, 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 percent "tipped," some wait until 75 percent tipped, and others follow UCCE guidelines of 100 percent or fully tipped.

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

E.2 Industry Trends in the Use of GHG Mitigation 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 (representing over 20 percent 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 percent of the fields did not use winter flooding from 2007 to 2010 (Table D.1). Of the 60 percent of the fields that did use winter flooding at some point, less than one percent of the fields winter flooded for all four years. The data from the other irrigation districts (RD 108, Richvale, and Western Canal) showed similar variability in the fraction of fields with winter flooding.

Table E.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, multi-temporal remote sensing data (MODIS and Landsat) was analyzed in order 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 during the other years; and 40 percent of acres appear to never be flooded during the five year interval investigated. Data reported in the background paper[82] affirm these same findings over a longer historical period. Therefore, reduced winter flooding (i.e. the

[82] Background paper will be made available on the Climate Action Reserve website.

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 in any given year under "business as usual." These findings, combined with concerns about negative impacts on waterfowl habitat, led to a decision to 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 into 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 includes 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 3) supply and storage problems.

Until 1991, burning rice straw was the most common practice. Following the 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 to 12 percent of rice acreage in California.[83]

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 (CalRice) for baling in California is 6 to 8 percent of the acreage per year. This estimate was further corroborated by the Reserve through analysis of previous research,[84] and through the use of a survey of University of California Cooperative Extension (UCCE) rice farm advisors and straw balers in California. Results from the survey suggest that rice baling has declined in recent years due to a loss of demand from the building and construction industry. Estimates from UCCE Rice Farm Advisors ranged from 2 to 6 percent 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 one to two tons of rice straw per acre out of approximately three tons per acre that is produced. Therefore, anywhere from 50 percent to 33 percent of the rice straw remains on the field. On an annual basis, 80 to 84 percent of all rice fields have 100 percent of the rice straw incorporated into the soil.

[83] Personal communication with Paul Buttner.
[84] Garnache et al., 2011.

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 to 7 percent of the acreage. Thus, the Reserve has concluded that switching from rice straw incorporation to baling constitutes an additional GHG reduction practice in California.

Dry Seeding

According to the USDA Economic Research Service 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 percent according to the ERS data.[85] 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 percent of the rice acreage in California.

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 percent of the acreage. Thus, the Reserve has concluded that switching from water seeding to dry seeding constitutes an additional GHG reduction practice in California.

[85] Livezy et al., 2001, Table 5, pg.10.

Appendix F Wildlife Habitat Conservation and the Rice Industry

In California's Central Valley, approximately 95 percent of the original existing wetlands have been converted from their natural state.[86]

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 habitat. 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, seven million waterfowl and several hundred thousand shorebirds are supported by rice lands annually,[87] 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.[88] 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) than fields where the rice straw residue had been removed (by baling).[89]

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 versions of this protocol. Should it be determined that a certain activity is resulting in negative impacts, mitigation options and/or changes in approved project activities may be required under subsequent protocol versions.

[86] Petrie, M., & Petrik, K. (May 2010).
[87] Ibid.
[88] Sterling, J., & Buttner, P. (2009).
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