California Environmental Protection Agency

AIR RESOURCES BOARD

Compliance Offset Protocol
Rice Cultivation Projects

Adopted: June 25, 2015

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Chapter 1. Purpose and Definitions

1.1. Purpose

(a) The purpose of the Compliance Offset Protocol Rice Cultivation Projects (protocol) is to quantify and report greenhouse gas (GHG) emission reductions associated with changes in rice cultivation practices that would otherwise be released to the atmosphere as a result of conventional rice cultivation practices.

(b) AB 32 exempts quantification methodologies from the Administrative Procedure Act (APA);[1] however, those elements of the protocol are still regulatory. The exemption allows future updates to the quantification methodologies to be made through a public review and Board adoption process, but without the need for rulemaking documents. Each protocol identifies sections that are considered quantification methodologies and exempt from APA requirements. Any changes to the non-quantification elements of the offset protocols would be considered a regulatory update subject to the full regulatory development process of the APA. Those sections that are considered to be a quantification methodology are clearly indicated in the title of the chapter or subchapter if only a portion of that chapter is considered part of the quantification methodology of the protocol.

1.2. Definitions

(a) Definitions. For the purpose of this protocol, the following definitions shall apply:

(1) "Accuracy" is as defined in section 95102 of the Mandatory Reporting Regulation.

(2) "Baseline Period," in the context of this protocol, means a period of at least five years immediately prior to the commencement of a project that comprises at least two cropping cycles. Each cropping cycle must include at least one rice cultivation year. Rice cultivation years that occur during a temporary emergency as specified in subchapter 5.2.2.1(o) are included in the baseline period but are not used for the determination of the baseline scenario.

[1] Health and Safety Code section 38571.

(3) “Baseline Scenario” means a counterfactual scenario that forecasts the likely stream of emissions or removals to occur if the Offset Project Operator does not implement the project.

(4) “Butte Sink Wildlife Management Area” means the area as defined by U.S. Fish and Wildlife Service at http://www.fws.gov/refuge/butte_sink/. (Last accessed 02/10/2014.)

(5) “Calibration” or “Model Calibration” means the process of tuning the coefficients of model parameters of a process-based model such as the De-nitrification De-Composition (DNDC) model to observations.

(6) “Cap-and-Trade Regulation” or “Regulation” means ARB’s regulation establishing the California Cap on Greenhouse Gas Emissions and Market-Based Compliance Mechanisms set forth in title 17, California Code of Regulations Chapter 1, Subchapter 10, article 5 (commencing with section 95800).

(7) “Checks” or “Basins” mean a sub-unit of a field separated by water control structures called levees or low dikes that are employed to control water distribution.

(8) “Cropping Cycle” or “Rotational Cropping Cycle” means the sequence of a cropping system. For example, if a cropping system is wheat-wheat-rice, then a complete cropping cycle is three cultivation years.

(9) “Cultivation Year” or “Year” means the period between the first day after harvest of the last crop in a field and the last day of harvest of the current crop in a field. Winter crops and ratooning are included as part of the subsequent crop’s reporting period. A cultivation year can also be a fallow year that starts the day after the harvest of the previous cultivation year and ends the day before the land preparation starts for the following cultivation year. A cultivation year is approximately 12 months. Each cultivation year is a reporting period.

(10) “DD50” or “DD50 Model” means a computerized rice management program developed by the University of Arkansas Division of Agriculture and maintained by a public university that assists with management

decisions based on rice growth stages. All values used from the DD50 model must be from a run at the end of the growing season.

(11) “Draining” means stopping water applications to a flooded or non-flooded field and/or removing water out of the field to expose soil.

(12) “Dry Seeding” means sowing of dry seeds into dry or moist, non-puddled or non-flooded soil.

(13) “Fallow Year” means a field is left unseeded during a growing season.

(14) “Field” or “Rice Field” means a contiguous parcel of land with homogeneous management on which rice is grown semi-continuously (i.e., at least one out of the last three cultivation years). A Rice Field usually has one water source inlet and one outlet and is usually separated into checks inside of perimeter levees that delineate the field’s boundaries.

(15) “Flooded Field” means a rice field that is completely inundated by water, with no visible soil or mud.

(16) “Heading” means the time when the panicle begins to exsert from the boot. It may take over 10 to 14 days for heading to take place due to variations within tillers on the same plant and between plants in the field.

(17) “Fifty-percent Heading Date” means the date that fifty percent of the tillers and main stems have their panicle fully emerged from the boot.

(18) “Historical Period” means a historical period for at least 20 years used for model simulation to allow the DNDC model to attain equilibrium in specific critical variables for which empirical data is lacking.

(19) “Inflorescence” means a group or cluster of flowers arranged on a stem that is composed of a main branch or a complicated arrangement of branches.

(20) “Mandatory Reporting Regulation” or “MRR” means ARB’s regulation establishing the Mandatory Reporting of Greenhouse Gas Emissions set forth in title 17, California Code of Regulations Chapter 1, Subchapter 10, article 2 (commencing with section 95100).

(21) “Model Parameter” means a data item that is supplied as input to a process-based model.

(22) "Model Validation" means the process of evaluating calibrated model results using field-measured data and quantifying the residual (structural) uncertainty.

(23) "Monte Carlo Simulation" means a broad class of computational algorithms that rely on repeated random sampling to obtain numerical results; typically one runs simulations many times over in order to obtain the distribution of an unknown probabilistic entity.

(24) "Panicle" means a branched inflorescence.

(25) "Parameterization" means the selection of Model Parameters that a process-based model such as DNDC will use for simulation.

(26) "Precision" means the degree to which repeated measurements under unchanged conditions show the same results.

(27) "Primary Effect" means the direct or intentional effect as a result of a project. Primary effect emissions mainly come from sources within the biogeochemical process that the DNDC model simulates.

(28) "Project Activity," for purposes of this protocol, means changes in agronomic management that leads to a reduction in GHG emissions in comparison to the baseline management and GHG emissions.

(29) "Project Area," for purposes of this protocol, means a rice field or a group of rice fields on which project activities take place.

(30) "Project Commencement Date" means, for the purposes of this protocol, the earliest first day on any field in the project area of the first rice cultivation year of a project.

(31) "Ratooning" means a method of harvesting a crop which leaves the roots and the lower parts of the plant uncut to give the rice plants the ability regenerate new tillers after harvest.

(32) "Regional Calibration" means the specific steps required to Calibrate and Validate the DNDC model for a Rice Growing Region and specific Project Activities.

(33) "Reporting Period" means, for the purposes of this protocol, a cultivation year for rice, rotation crop or fallow year. When a project comprises

multiple rice fields, the reporting period starts on the earliest first day of a cultivation year of a field in the project and ends on the latest last day of a cultivation year of a field in the project.

(34) "Rice Growing Region" means a geographic region in which the climate and rice management practices are relatively homogeneous. There are two major Rice Growing Regions in the United States: California Rice Growing Region and Mid-South Region. California Rice Growing Region includes Sacramento Valley only. Mid-South Rice Growing Region includes (1) Mississippi River Delta mainly in Arkansas, extending into Mississippi and Missouri and (2) Gulf Coast area in Louisiana. A Rice Growing Region represents the geographical region that reflects the area over which one Calibration of the DNDC model remains valid.

(35) "Rotation Crop" means the crop planted as part of the practice of growing a series of dissimilar types of crops in the same area in sequential seasons.

(36) "Secondary Effect" means indirect or unintentional changes as a result of a project. Secondary effect emissions mainly come from sources such as farming equipment that is used for land preparation, irrigation, sowing, harvesting, transporting, etc.

(37) "Start Date" means the start of the cultivation year for the first rice field in the Project, as determined per section 3.6.

(38) "Structural Uncertainty" means the inherent uncertainty of process-based models that remains even if all input data were error-free.

(39) "Thermal Degree Days" or "Thermal Degree Days for Maturity" means accumulative air temperature from seeding till maturity of the crop.

(40) "Unadjusted emissions" means emission reductions calculated prior to applying an uncertainty deduction.

(41) "Uncertainty Deduction" means deduction, accounting for both uncertainty in input parameters and model structural uncertainty, applied to the emission reductions calculated by DNDC to ensure that credited emission reductions remain conservative.

(42) "Wet Seeding" means sowing pre-germinated seed or sprouted seeds into puddled soil.

(b) For terms not defined in section 1.2(a), the definitions in the Regulation apply.

(c) Acronyms. For purposes of this protocol, the following acronyms shall apply:

(1) "ARB" means the California Air Resources Board.

(2) "AWD" means alternate wetting and drying.

(3) "CIMIS" means California Irrigation Management Information System operated by California Department of Water Resources.

(4) "DNDC" means DeNitrification and DeComposition model.

(5) "ha" means hectare.

(6) "HP" means horsepower.

(7) "kg" means kilogram.

(8) "MT" means metric ton.

(9) "N_2O" means nitrous oxide.

(10) "OPDR" means Offset Project Data Report.

(11) "PRISM" means Parameter elevation Regression on Independent Slopes Model.

(12) "SOC" means soil organic carbon.

(13) "SSR" means greenhouse gas sources, sinks, and reservoirs.

(14) "SSURGO Database" means Soil Survey Geographic (SSURGO) Database.

(15) "STATSGO Database" means State Soil Geographic (STATSGO) Database.

(16) "TDD" means thermal degree days for maturity.

Chapter 2. Eligible Project Activities – Quantification Methodology

This protocol includes three rice cultivation project activities designed to reduce GHG emissions that result from rice cultivation on fields in the California and Mid-South Rice Growing Regions. The following types of rice cultivation activities are eligible:

2.1 Dry Seeding Activities

This protocol applies to rice cultivation projects that sow seeds into a dry or moist, but not flooded, seedbed by drilling or broadcasting seeds onto rice fields, resulting in the reduction of methane that would otherwise be released into the atmosphere if the seeds were wet-seeded.

(a) For dry seeding activities, permanent flooding must be delayed until the rice stand is established to a four to six-leaf stage.

(b) The management records specified in appendix A for the baseline period for rice fields implementing dry seeding activities must be available.

(c) Only fields that were wet seeded during each rice cultivation year of the baseline period are eligible for crediting.

(d) Dry-seeding activities are only eligible for crediting in the California Rice Growing Region.

2.2 Early Drainage in Preparation for Harvest Activities

This protocol applies to rice cultivation projects that drain or dry standing water, while the soil is still saturated, from rice fields earlier during the rice growing season in preparation for harvest, resulting in the reduction of methane that would otherwise be released into the atmosphere if the rice fields were drained or dried on the customary date.

(a) The management records specified in appendix A for the baseline period for rice fields implementing early drainage in preparation for harvest activities must be available.

(b) Early drainage in preparation for harvest activities must follow one of the requirements below (based on project location):

 (1) For early drainage in preparation for harvest activities in the California Rice Growing Region, a participating field must be fully saturated 24 days after fifty-percent heading. Rice crop from each field must be sampled to determine fifty-percent heading using the following criteria:

  (A) At least three rice plant samples must be taken;

  (B) No sample shall be taken within a 50-foot radius of the water inlet or within the area impacted by cold water;

(C) All samples shall be equally spaced in the field, to the extent possible, and samples must be representative of heading and address field variability;

(D) Each sample must cut all the tillers and main stems in at least a one square foot area with uniform plant maturity;

(E) Samples will be combined then separated into two categories:

1. Heading; and
2. Not heading;

(F) Greater than or equal to fifty-percent of the tillers and main stems must be heading;

(G) If less than fifty-percent of tillers and main stems are heading the field must be resampled until there is at least fifty-percent heading; and

(H) Standard procedures must be used for the collection of field samples. These procedures must be detailed enough so that a qualified agronomist would be able to accurately reproduce the fifty-percent heading determination.

(2) For early drainage in preparation for harvest activities in the Mid-South Rice Growing Region, drainage may begin when ninety-five percent of main stem panicles have at least one yellow hull grain. Rice crop from each field must be sampled to determine yellow hull existence using the following criteria:

(A) At least three rice plant samples must be taken;

(B) No sample shall be taken within a 50-foot radius of the water inlet or within the area impacted by cold water;

(C) All samples shall be equally spaced in the field, to the extent possible and samples must be representative and address field variability;

(D) Each sample must cut all the tillers and main stems in at least a one square foot area with uniform grain maturity;

(E) Samples will be combined then separated into two categories:

1. Main stem panicles with at least one yellow hull grain; and
2. Main stem panicles without a yellow hull grain;

(F) Greater than or equal to ninety-five percent of all main stem panicles must contain at least one yellow hull grain;

(G) If less than ninety-five percent but greater than or equal to eighty percent of all main stem panicles have at least one yellow hull grain, resampling is not required. In this case drainage may begin six days after the sampling; and

(H) Standard procedures must be used for the collection of field samples. These procedures must be detailed enough so that a qualified agronomist would be able to accurately reproduce the percent yellow hull determination.

(c) For wildlife conservation purposes in the California Rice Growing Region, no more than 90% of a participating field's perimeter may be shared with a public road, a field that is also employing early drainage in preparation for harvest activities or land zoned for commercial, industrial, residential, planning, special, or mixed use to be eligible for crediting.

(d) Fields whose tail water flows directly into a natural wetland, which has no standing water at the beginning of the drainage, without going through another rice field, drain canal, or irrigation canal first, are not eligible for crediting.

(e) Early drainage in preparation for harvest activities located in both the California and Mid-South Rice Growing Regions are eligible for crediting.

(f) Early drainage in preparation for harvest activities for ratoon crops are not eligible for crediting.

2.3 Alternate Wetting and Drying Activities

(a) This protocol applies to rice cultivation projects that cyclically wet and dry the rice fields during the growing season to reduce methane emissions that would otherwise be released into the atmosphere if the project employed continuous flooding.

(b) The management records specified in appendix A for the baseline period for rice fields implementing AWD activities must be available.

(c) For AWD activities, the following requirements apply and soil moisture readings must be taken as specified below.

(1) At the end of each "drying," the soil at 10 centimeters depth must reach a non-saturated point, but maintain a moisture level above fifty percent.

(2) At the end of each "drying," areas of the rice field that are still saturated with water or with a moisture level below fifty percent are ineligible for crediting.

(3) For fields that are not zero-percent graded but sloped towards the water outlet at least two soil moisture readings must be taken: one within a 50-foot radius of the water inlet and one within a 50-foot radius of the water outlet.

(4) For fields that are zero-percent graded, the following requirements apply:

(A) A field that is less than or equal to 50 acres must have at least three equally spaced, to the extent possible, soil moisture readings taken, including one within a 50-foot radius of the water inlet and one within a 50-foot radius of the water outlet. Samples must be representative of soil moisture and address field variability; or,

(B) A field that is greater than 50 acres must have at least five equally spaced, to the extent possible, soil moisture readings taken, including one within a 50-foot radius of the water inlet and one within a 50-foot radius of the water outlet. Samples must be representative of soil moisture and address field variability.

(5) A soil moisture reading shall be taken using a stationary or portable soil moisture sensor that can generate instant soil moisture readings.

(A) Each soil moisture sensor must be checked for accuracy at least once every reporting period for which AWD activities are employed and before the AWD activities start.

(B) If the check in a soil moisture sensor reveals accuracy beyond a +/-5% threshold (reading relative to the reference value,) corrective action such as calibration by the manufacturer or a certified service provider is required.

(C) Each soil moisture sensor must be calibrated at least once every five years or according to the manufacturer's recommendation or product specifications, whichever is more frequent.

(D) Instruments are exempted from calibration requirements if the manufacturer's specifications state that no calibration is required.

(E) The standard procedures for taking soil moisture readings must be recorded and retained per section 95976 of the Regulation and subchapter 6.2.3.

(F) The standard procedures for taking soil moisture readings must be detailed enough to be replicable. These procedures must include:

1. A description of soil moisture reading procedures;
2. The location of readings; and
3. A description of the equipment used for soil moisture readings.

(6) If a soil moisture reading was not taken using a calibrated soil moisture sensor, then the field is considered flooded until the next successful soil moisture reading is taken and GHG reductions will not be accounted for or credited.

(7) The soil moisture sample method described in Appendix D may also be used.

(d) Only AWD projects located in the Mid-South Rice Growing Region are eligible for crediting.

(e) AWD activities for ratoon crops are not eligible for crediting.

Chapter 3. Eligibility

In addition to the offset project eligibility criteria and regulatory program requirements set forth in the Regulation, rice cultivation offset projects must adhere to the eligibility requirements below.

3.1 General Eligibility Requirements

(a) Offset projects developed using this protocol must:

(1) Only include rice fields in the project area that have planted rice for at least two rice cultivation years in the baseline period before the project commencement;

(2) Grow rice of the same maturity characteristics during the crediting period as the baseline period;

(3) Employ homogeneous water, fertilizer, and crop residue management across each individual, participating rice field within each reporting period;

(4) Have at least two years of rice yield data and management data specified in appendix A for each field for the entire baseline period;

(5) Employ one or multiple eligible activities as specified in chapter 2. All fields do not need to employ the same eligible activities;

(6) Have soil with organic carbon content less than or equal to 3.00% in the top ten centimeters of soil in each eligible field;

(A) If the organic content of a field is available through a laboratory testing, as specified in subchapter 3.1(a)(6)(D)3., the tested soil sample results must be used.

(B) If a laboratory tested sample result is unavailable, the organic content of a field must be determined using SSURGO data posted on ARB's Rice Protocol Resources website.

1. Mean SSURGO attributes for a rice field must be calculated using the methods available on the U.S. Department of Agriculture Natural Resources Conservation Service Web Soil Survey (accessible at: http://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm).
2. If the Web Soil Survey is unavailable, the methods in subchapter 3.1(a)(6)(C) must be used.

(C) If SSURGO data is not available, STATSGO2 data posted on ARB's Rice Protocol Resources website must be used.

1. For each component, calculate representative depth-weighted total clay ("claytotoal_r"), organic matter ("om_r"),

bulk density (“dbthirdbar_r”) and pH(“ph1to1h20_r”) using horizons ≤ 10cm.

2. Calculate area-weighted soil attributes for each map unit based on component percentage (“comppct”).
3. Calculate area-weighted soil attributes for the rice field based on the map-unit fractions.
4. For clay content, total clay percentage must be converted to clay fraction (%clay/100.0).
5. For soil organic carbon (SOC) at surface, organic matter (OM) percentage must be divided by 200 (SOC=OM/200.0).
6. If greater than 50.0% of the total soil volume contains components with missing data, an alternative database or method must be used.

(D) If neither SSURGO or STATSGO2 data is available, one of the following methods must be chosen to determine soil characteristics:

1. A government soil database;
2. A state university published soil database; or
3. Soils samples may be taken to determine the soil parameters, for a participating field. Soil samples must be taken per USDA’s Soil Quality Test Kit Guide (July 2001), available at http://www.nrcs.usda.gov/Internet/FSE_DOCUMENTS/nrcs142p2_051290.pdf [2] and tested by a USDA APHIS inspected facility authorized to receive soil (http://www.aphis.usda.gov/wps/portal/aphis/ourfocus/planthealth?1dmy&urile=wcm%3apath%3a%2Faphis_content_library%2Fsa_our_focus%2Fsa_plant_health%2Fsa_import%2Fsa_permits%2Fsa_plant_pests%2Fsa_soil%2Fct_soil_labs[3]).)

(7) Have not generated ARB or voluntary registry offset credits for fallow or rotation crop years; and

[2] Last accessed 03/12/2014.
[3] Last accessed 03/12/2014.

(8) Have not grown wild rice cultivars since the first year of the baseline period.

(b) Offset Project Operators or Authorized Project Designees that use this protocol must:

(1) Provide the listing information required by section 95975 of the Regulation and subchapter 7.1 of this protocol;

(2) Monitor GHG emission sources and sinks within the GHG Assessment Boundary as delineated in chapter 4 per the requirements of chapter 6;

(3) Quantify GHG emission reductions per chapter 5;

(4) Prepare and submit annual Offset Project Data Reports (OPDRs) that includes the information requirements in subchapter 7.2; and

(5) Obtain offset verification services from an ARB-accredited offset verification body in accordance with section 95977 of the Regulation and chapter 8.

3.2 Location

(a) Only projects located in an approved Rice Growing Region for which the DNDC model has been calibrated and validated against field measured methane emission, and a regional performance standard has been evaluated, are eligible for crediting.

(b) Only projects located in the following Rice Growing Regions are eligible:

(1) California Rice Growing Region defined as Sacramento Valley, but outside of the Butte Sink Wildlife Management Area.

(2) Mid-South Rice Growing Region defined as:

(A) Mississippi River Delta in Arkansas, Mississippi and Missouri; and

(B) Gulf Coast area in Louisiana.

(c) An offset project situated on the following categories of land is only eligible under this protocol if it meets the requirements of this protocol and the Regulation, including the waiver of sovereign immunity requirements of section 95975(l) of the Regulation:

(1) Land that is owned by, or subject to an ownership or possessory interest of a Tribe;

(2) Land that is "Indian lands" of a Tribe, as defined by 25 U.S.C. §81(a)(1); or

(3) Land that is owned by any person, entity, or Tribe, within the external borders of such Indian lands.

3.3 Offset Project Operator or Authorized Project Designee

(a) The Offset Project Operator or Authorized Project Designee is responsible for project listing, monitoring, reporting, and verification.

(b) The Offset Project Operator or Authorized Project Designee must submit the information required by Subarticle 13 of the Regulation and in chapter 7 of this protocol.

(c) The Offset Project Operator must have legal authority to implement the offset project.

(d) For purposes of this protocol, the Offset Project Operator must be either the land owner or lessee.

(e) Within 90 calendar days of a change of Offset Project Operator due to a change of land ownership, management or tenant occupancy, the new Offset Project Operator must submit to both ARB and the offset project registry (OPR) the following information which will be made public:

(1) The name, address, phone number, and E-mail address of the new Offset Project Operator;

(2) The offset project name and ARB identification number;

(3) The date of change of land ownership, management or tenant occupancy; and

(4) The signed attestations found in section 95975(c) of the Regulation.

(f) If the new Offset Project Operator elects to continue the project they must continue the existing project and crediting period. Upon the end of the current crediting period, the new Offset Project Operator may opt to renew the project pursuant to section 95957 of the Regulation using the existing project's baseline.

3.4 Additionality

Offset projects must meet the additionality requirements set forth in section 95973(a)(2) of the Regulation, in addition to the requirements in this protocol. Eligible offsets must be generated by projects that yield additional GHG reductions that exceed any GHG reductions otherwise required by law or regulation or any GHG reductions that would otherwise occur in a conservative business-as-usual scenario. These requirements are assessed through the Legal Requirement Test in subchapter 3.4.1 and the Performance Standard Evaluation in subchapter 3.4.2.

3.4.1 Legal Requirement Test

(a) Emission reductions achieved by a Rice Cultivation project must exceed those required by any law, regulation, or legally binding mandate as required in sections 95973(a)(2)(A) and 95975(n) of the Regulation.

(b) The following legal requirement test applies to all Rice Cultivation projects:

  (1) If no law, regulation, or legally binding mandate requiring the implementation of project activities at the field(s) in which the project is located exists, all emission reductions resulting from the project activities are considered to not be legally required, and therefore eligible for crediting under this protocol.

  (2) If any law, regulation, or legally binding mandate requiring the implementation of project activities at the field(s) in which the project is located exists, only emission reductions resulting from the project activities that are in excess of what is required to comply with those laws, regulations, and/or legally binding mandates are eligible for crediting under this protocol.

3.4.2 Performance Standard Evaluation

(a) Emission reductions achieved by a Rice Cultivation project must exceed those likely to occur in a conservative business-as-usual scenario.

(b) The performance standard evaluation is satisfied by the following activities, depending on project location:

  (1) Dry Seeding Activities only in the California Rice Growing Region.

  (2) Early Drainage in Preparation for Harvest Activities in both the California and Mid-South Rice Growing Regions.

(3) Alternate Wetting and Drying Activities only in the Mid-South Rice Growing Region.

3.5 Methane Source Boundaries

(a) The methane emission reductions from the rice cultivation protocol must be from project activities that reduce methane emissions that would otherwise be emitted into the atmosphere during the course of normal rice cultivation activities.

(b) The physical boundaries for an offset project for all project activities, are one or more rice fields.

(c) Only reductions in methane emissions are eligible for ARB offset credits. GHG emission reductions or removal enhancements due to changes in N_2O or SOC are not eligible for crediting under this protocol.

3.6 Offset Project Commencement

(a) The offset project commencement date is the first day of the cultivation year during which a project activity is first implemented.

(b) Per section 95973(a)(2)(B) of the Regulation, compliance offset projects must have an offset project commencement date after December 31, 2006.

3.7 Reporting Period

(a) For the purposes of this protocol, the reporting period is defined as a cultivation year or a fallow year.

(b) The first reporting period of a project may comprise one or two cultivation years.

(c) The planting and harvesting of a winter crop is not an individual reporting period. A winter crop is included in the same reporting period as the following growing season crop.

(d) For a fallow year, the reporting period ends the day before the land preparation for the next crop starts.

(e) A reporting period is approximately a twelve-month period.

(f) A rotation crop year or fallow year is a reporting period. The Offset Project Operator and/or Authorized Project Designee must indicate this situation in the OPDR for that reporting period and should report zero GHG emission reductions.

(g) The Offset Project Operator or Authorized Project Designee must submit an OPDR for each reporting period.

(h) A reporting period with zero GHG emission reductions can be verified in the verification performed for the next rice cultivation year as specified in subchapter 8.1(b).

(i) Each reporting period must have an individual verification statement.

3.8 Project Crediting Period

The crediting period for this protocol is ten reporting periods.

3.9 Regulatory Compliance

(a) An offset project must meet the regulatory compliance requirements set forth in section 95973(b) of the Regulation.

(b) An offset project is not eligible to receive Registry or ARB offset credits for a corresponding reporting period if any parameter entered into the DNDC model is a result of a regulatory violation, consent order, Memorandum of Understanding, or other required mitigation measures.

(c) A regulatory violation, as specified in subchapter 3.9(b), does not affect crediting for the succeeding reporting periods.

3.10 Ratooning

(a) Ratooning is a winter crop and subject to all winter crop related provisions in this protocol.

(b) Ratooning is not allowed for a participating rice field in a reporting period unless:

(1) Ratooning took place legally in one of the rice growing years, during the baseline period; and

(2) A suitability demonstration for ratooning in a reporting period is supported and attested to by a local or state agricultural cooperative rice farming advisor.

(c) The suitability demonstration of ratooning must include an analysis of:

(1) The inherent ratooning ability of the cultivar,

(2) The suitability of light,

(3) The suitability of temperature,

(4) The suitability of soil moisture,

(5) The suitability of fertility,

(6) Rice cultivation practice management, and

(7) Main-crop growth duration.

Chapter 4.GHG Assessment Boundary - Quantification Methodology

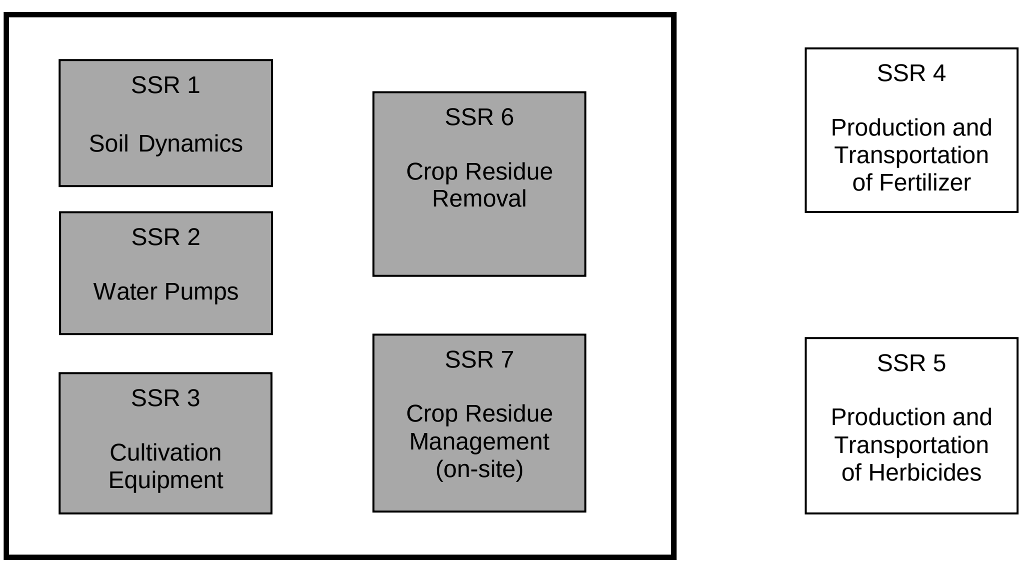
The greenhouse gas assessment boundary, or offset project boundary, delineates the SSRs that shall be included or excluded when quantifying the net change in GHG emissions associated with the adoption of eligible rice cultivation activities. The following GHG assessment boundaries apply to all rice cultivation projects.

4.1 Greenhouse Gas Assessment Boundary

(a) Figure 4.1 illustrates the GHG assessment boundary of rice cultivation projects, indicating which SSRs are included or excluded from the offset project boundary.

(b) All SSRs within the bold line are included and must be accounted for under this protocol.

Figure 4.1. Illustration Of The Greenhouse Gas Assessment Boundary For Rice Cultivation Projects.



(c) Table 4.1indicates which gases are included or excluded from the offset project boundary.

Table 4.1. List of the Greenhouse Gas Sources, Sinks, and Reservoirs for Rice Cultivation Projects

SSR	Description	GHG	Baseline Scenarios (B) or Project (P)	Included/ Excluded	Quantification Method	Explanation
Primary Effect Sources, Sinks, and Reservoirs						
1	The biogeochemical interaction between soil, plants, and nutrients that produce greenhouse gases including CO_2, CH_4, N_2O, and changes in soil carbon stocks.	CO_2	B,P	Included (debit only)	DNDC	May be significant changes in CO_2 emissions due to changes in soil carbon stocks as a result of project activities.
		CH_4	B,P	Included	DNDC	Primary effect of the protocol is reduction in CH_4 emissions due to reduced organic decomposition as a result of reduced flooding.
		N_2O	B,P	Included (debit only)	DNDC	May be a significant source of emissions if project activities affect fertilizer application or practices.
Secondary Effect Sources, Sinks, and Reservoirs						
2	Indirect fuels or electricity used to operate water pumps to transport water onto fields.	CO_2	B,P	Excluded	N/A	Project activities are likely to only decrease (which is not credited) or not impact fossil fuel use.
		CH_4	N/A	Excluded	N/A	Assumed to be small, excluded to simplify accounting.
		N_2O	N/A	Excluded	N/A	Assumed to be small, excluded to simplify accounting.
3	Greenhouse gas emissions as a result of equipment use for rice cultivation activities.	CO_2	B,P	Included (debit only)	Emission Factors	Emissions may be significant if project activities alter management practices.
		CH_4	N/A	Excluded	N/A	Assumed to be small, excluded to simplify accounting.
		N_2O	N/A	Excluded	N/A	Assumed to be small, excluded to simplify accounting.
4	Greenhouse gas emissions from	CO_2	N/A	Excluded	N/A	Incremental increase assumed to

SSR	Description	GHG	Baseline Scenarios (B) or Project (P)	Included/ Excluded	Quantification Method	Explanation
	manufacturing and transporting fertilizer to rice fields					be small, excluded to simplify accounting.
		CH_4	N/A	Excluded	N/A	Assumed to be small, excluded to simplify accounting.
		N_2O	N/A	Excluded	N/A	Assumed to be small, excluded to simplify accounting.
5	Greenhouse gas emissions from manufacturing and transporting herbicide to rice fields	CO_2	N/A	Excluded	N/A	Incremental increase assumed to be small, excluded to simplify accounting.
		CH_4	N/A	Excluded	N/A	Assumed to be small, excluded to simplify accounting.
		N_2O	N/A	Excluded	N/A	Assumed to be small, excluded to simplify accounting.
6	Greenhouse gas emissions as a result of equipment use for collecting and removing rice straw from rice fields (on-site)	CO_2	P, B	Included (debit only)	Emission Factors	Emissions may be significant if project activities alter residue management.
		CH_4	P,B	Excluded	N/A	Assumed to be small, excluded to simplify accounting.
		N_2O	P, B	Excluded	N/A	Assumed to be small, excluded to simplify accounting.
7	Greenhouse gas emission from on-site rice crop residue management	CO_2	P, B	Included (debit only)	Emission Factors	May be a significant source of emissions for rice straw burning
		CH_4	P, B	Included (debit only)	Emission Factors	May be a significant source of emissions from anaerobic decomposition of rice straw base on end use
		N_2O	N/A	Excluded	N/A	Assumed to be small, excluded to simplify accounting.

Chapter 5. Quantifying GHG Emission Reductions - Quantification Methodology

(a) GHG emission reductions from a rice cultivation project are quantified by comparing actual project emissions to project baseline emissions that would have occurred in the absence of the rice cultivation project.

(b) Offset Project Operators and Authorized Project Designees must use the calculation methods provided in this protocol to determine baseline and project GHG emissions.

(c) GHG emission reductions must be quantified on a reporting period basis.

(d) Global warming potential values must be determined consistent with the definition of Carbon Dioxide Equivalent in MRR section 95102(a).

5.1 Calculating GHG Emission Reductions

(a) Total GHG emission reductions (ER) for each project for a reporting period must be quantified by subtracting secondary emission increases (SE) from modeled primary emission reductions (PER) using equation 5.1.

Equation 5.1 Calculating GHG Emission Reductions for Each Project

$$ER = PER - SE$$

Where,			Units
ER	=	Total emission reductions from the project area for the reporting period	$MTCO_2e$
PER	=	Total modeled primary source GHG emission reductions from soil dynamics (SSR 1) during the reporting period	$MTCO_2e$
SE	=	Total secondary source GHG emission increases caused by project activity during the reporting period	$MTCO_2e$

(b) Total modeled primary source GHG emission reductions (PER) must be calculated using the DNDC model as specified in subchapter 5.2.

(c) Total secondary source GHG emission increases (SE) must be calculated as specified in subchapter 5.3.

5.2 Modeled Primary Emission Reductions

(a) Quantifications performed in this section must use the DNDC model posted on ARB’s Rice Protocol Resources website.

(b) Modeled primary emission reductions for each rice field must be calculated following these procedures:

  (1) Perform a field-specific calibration on the DNDC model, as specified in subchapter 5.2.1;

  (2) Quantify unadjusted baseline GHG emissions, as specified in subchapter 5.2.2;

  (3) Quantify unadjusted project GHG emissions, as specified in subchapter 5.2.3; and

  (4) Quantify primary emission reductions for the project, as specified in subchapter 5.2.4.

(c) For steps identified in subchapter 5.2(b), the DNDC model must be populated with climate, soil, and cropping data for the applicable rice field(s) within the project (see table 6.1 for required parameters). Use the DNDC default values for parameters not specifically identified in this protocol.

  (1) Soil data must be obtained per subchapter 3.1(a)(6).

  (2) Daily climate data must include daily data on precipitation, maximum temperature, and minimum temperature and must be obtained from the closest weather station, including CIMIS weather stations, located within an elevation difference of no more than 300 feet from the project location, if available. If the project is located in an air basin, the weather station must be located within the same air basin, if available. Alternatively, weather station-based reanalysis products, including PRISM model, may be used.

  (3) Farming management practice parameters that must be monitored include: crop, tillage, fertilization, manure management, irrigation, flooding, plastic film use, and grazing or cutting information.

  (4) Cropping data for baseline scenarios must be determined per subchapter 5.2.2.1.

(5) Farming management practices for projects must be determined based on actual data.

(6) Detailed model parameters are listed in table 6.1.

(d) DNDC variable data format must be consistent with what is specified in the DNDC User Guide posted on ARB's Rice Protocol Resources website.

5.2.1 Field-Specific Crop Calibration

(a) A field specific crop yield calibration for the DNDC model must be performed once for the historical period and again for each reporting period for every project before all other quantification starts. The field specific crop yield calibration for the DNDC model must be performed in accordance with the requirements set forth in appendix B.

(b) The "Maximum biomass" and "Thermal degree days" values determined during the DNDC field specific crop yield calibration for each reporting period must be used for calculating unadjusted baseline and project emissions for the reporting period.

(c) Prior to modeling the unadjusted baseline and unadjusted project emissions for the first reporting period of each field, the DNDC crop yield parameters must be calibrated with baseline input data from the baseline period and input data from the first reporting period.

(d) Each subsequent reporting period must use input data from the reporting period to calibrate the DNDC crop yield parameters.

(e) Default crop parameters must be taken from table B.1.

5.2.2 Unadjusted Baseline GHG Emissions

(a) Unadjusted baseline GHG emissions must be quantified for each field for each reporting period with rice crop planted.

(b) The baseline scenario for each reporting period must be established pursuant to subchapter 5.2.2.1.

(c) For the initial reporting period, the unadjusted baseline modeling must be equilibrated with at least 20 years of historical data covering complete cropping cycles, including rotation crop(s) and fallow years, by repeating all parameters from the baseline period before the start of the crediting period four times. The 20-year spin up must include data for all crop and fallow years, not just rice crop years. The following data must be used:

(1) Soil data as specified in subchapter 3.1(a)(6);

(2) Actual climate data from the baseline period; and

(3) Baseline period historical farming management practices.

(d) For each subsequent reporting period in the crediting period, the unadjusted modeling must be equilibrated with at least 20 years of data from the baseline period as described in subchapter 5.2.2(c) and data from all preceding reporting periods in the crediting period.

(e) Unadjusted baseline GHG emissions for each rice field for a reporting period must be determined with the DNDC model based on the farming management information parameters determined for the baseline scenario in subchapter 5.2.2.1 and the soil and climate profile parameters for the reporting period being considered. The following soil parameters will be selected for variation:

(1) Soil clay;

(2) Bulk density;

(3) SOC content; and

(4) pH value.

(f) The direct GHG emission parameters identified in box 5.1 are retrieved from the DNDC runs.

Box 5.1. Recovered Baseline Parameters

Recovered Baseline Parameters			
$N_2O_{Dir,B,i,j}$	=	Baseline N_2O emissions from rice field i from Monte Carlo run j	kg N_2O -N/ha
$N_{Leach,B,i,j}$	=	Baseline nitrate leaching loss from rice field i from Monte Carlo run j	kg NO_3-N/ha
$N_{Vol,B,i,j}$	=	Baseline ammonia volatilization from rice field i from Monte Carlo run j	(kg NH_3-N + kg NO_x-N)/ha
$CH_{4\ B,i,j}$	=	Baseline CH_4 emissions from rice field i from Monte Carlo run j	kg CH_4-C/ha
$SOC_{B,i,j}$	=	Baseline soil organic carbon content from rice field i from Monte Carlo run j	Kg SOC-C/ha

(g) The unadjusted baseline GHG emissions may be quantified using either equation 5.2.1 or equation 5.2.2.

(h) When equation 5.2.1 is used for quantifying unadjusted baseline GHG emissions, equation 5.3.1 must be used for quantifying unadjusted project GHG emissions and equation 5.4.1 must be used for quantifying primary source GHG emission reductions for a project. When equation 5.2.2 is used for quantifying unadjusted baseline GHG emissions, equation 5.3.2 must be used for quantifying unadjusted project GHG emissions and equation 5.4.2 must be used for quantifying primary source GHG emission reductions for a project.

(i) The unadjusted baseline GHG emissions from 1,000 runs of Monte Carlo simulation for field i must be calculated using equation 5.2.1 below. To use equation 5.2.1, the 1,000 runs must use the values in box 5.2 to vary the soil parameters listed in subchapter 5.2.2(e).

Equation 5.2.1 Calculating Unadjusted Baseline GHG Emissions from 1,000 Monte Carlo Runs

$$\boldsymbol{N_2O_{B,i,j-CO2e}} = \left\{\boldsymbol{N_2O_{Dir,B,i,j}} + (\boldsymbol{N_{Leach,B,i,j}} \times \boldsymbol{EF_{Leach}}) + (\boldsymbol{N_{Vol,B,i,j}} \times \boldsymbol{EF_{Vol}})\right\} \times \mathbf{1.571} \times \boldsymbol{GWP_{N2O}}$$

$$\boldsymbol{CH_{4_{B,i,j-CO2e}}} = \boldsymbol{CH_{4_{B,i,j}}} \times \mathbf{1.333} \times \boldsymbol{GWP_{CH4}}$$

$$\boldsymbol{SOC_{B,i,j-CO2e}} = \boldsymbol{SOC_{B,i,j}} \times \mathbf{3.667}$$

Where,			Units
i	=	Fields	-
j	=	Monte Carlo runs (1,000)	-
$N_2O_{B,i,j-CO2e}$	=	The reporting period direct and indirect N_2O emissions for the baseline scenario from rice field i for Monte Carlo run j	kg CO_2e/ha
$N_2O_{Dir,B,i,j}$	=	Baseline N_2O emissions from rice field i from Monte Carlo run j	kg N_2O-N/ha
$N_{Leach,B,i,j}$	=	Reporting period nitrate leaching loss from rice field i for the baseline scenario from Monte Carlo run j	kg NO_3-N/ha

EF_{Leach}	=	Emission factor for N_2O emissions from N leaching and runoff, equal to 0.0075	kg N_2O-N/kg NO_3-N
$N_{Vol,B,i,j}$	=	Reporting period ammonia volatilization and nitric oxide emissions from rice field i for the baseline scenario from Monte Carlo run j	(kg NH_3-N + kg NOx-N) /ha volatized
EF_{Vol}	=	Emissions factor for N_2O emissions from atmospheric deposition of N on soils and water surfaces and subsequent volatilization, equal to 0.01	kg N_2O-N/(kg NH_3-N + kg NO_x-N)
1.571	=	Unit conversion from kg N_2O-N to kg N_2O	
$CH_{4\ B,i,j\text{-}CO2e}$	=	The reporting period CH_4 emissions for the baseline scenario from rice field i, for Monte Carlo run j	kg CO_2e/ha
$CH_{4\ B,i,j}$	=	Reporting period CH_4 emissions from rice field i for the baseline scenario from Monte Carlo run j	kg CH_4-C/ha
1.333	=	Unit conversion of C to CH_4	
$SOC_{B,i,j\text{-}CO2e}$	=	The reporting period soil organic carbon stored for the baseline scenario from rice field i, for Monte Carlo run j	kg CO_2e/ha
$SOC_{B,i,j}$	=	SOC content of rice field i on the last day of the reporting period for the baseline scenario from Monte Carlo run j	kg SOC-C/ha
3.667	=	Unit conversion of C to CO_2	
GWP_{N2O}	=	The GWP value for N_2O	
GWP_{CH4}	=	The GWP value for CH_4	

(j) The unadjusted baseline GHG emissions from sixteen runs of Monte Carlo simulations for field i must be calculated using equation 5.2.2 below. To use equation 5.2.2, the sixteen runs must comprise every possible combination of the minimum and maximum uncertainty values for each of the soil parameters shown in box 5.2.

Box 5.2 Soil Parameter Values Used for the Sixteen Runs of Monte Carlo Simulation for Each Rice Field

Parameter	Maximum Value	Minimum Value	Statistical Distribution
Bulk density	Soil Survey/Sample Value + 0.1 g/cm^3	Soil Survey/Sample Value - 0.1 g/cm^3	Log-Normal
Clay content	Soil Survey/Sample Value + 10%	Soil Survey/Sample Value - 10%	Log-Normal
SOC	Soil Survey/Sample Value + 20%	Soil Survey/Sample Value - 20%	Log-Normal
pH	Soil Survey/Sample Value + 1 pH unit	Soil Survey/Sample Value - 1 pH unit	Normal

Equation 5.2.2 Calculating Unadjusted Baseline GHG Emissions from 16 Monte Carlo Runs

$$N_2O_{B,i,j-CO2e} = \{N_2O_{Dir,B,i,j} + (N_{Leach,B,i,j} \times EF_{Leach}) + (N_{Vol,B,i,j} \times EF_{Vol})\} \times 1.571 \times GWP_{N2O}$$

$$CH_{4_{B,,i,j-CO2e}} = CH_{4_{B,i,j}} \times 1.333 \times GWP_{CH4}$$

$$SOC_{B,i,j-CO2e} = SOC_{B,i,j} \times 3.667$$

Where,

			Units
i	=	Fields	-
j	=	Monte Carlo runs (16)	-
$N_2O_{B,i,j-CO2e}$	=	The reporting period direct and indirect N_2O emissions for the baseline scenario from rice field i for Monte Carlo run j	kg CO_2e/ha
$N_2O_{Dir,B,i,j}$	=	Baseline N_2O emissions from rice field i from Monte Carlo run j	kg N_2O-N/ha
$N_{Leach,B,i,j}$	=	Reporting period nitrate leaching loss from rice field i for the baseline scenario from Monte Carlo run j	kg NO_3-N/ha
EF_{Leach}	=	Emission factor for N_2O emissions from N leaching and runoff, equal to 0.0075	kg N_2O-N/kg NO_3-N
$N_{Vol,B,i,j}$	=	Reporting period ammonia volatilization and nitric oxide emissions from rice field i for the baseline scenario from Monte Carlo run j	(kg NH_3-N + kg NOx-N) /ha

			volatized
EF_{Vol}	=	Emissions factor for N_2O emissions from atmospheric deposition of N on soils and water surfaces and subsequent volatilization, equal to 0.01	kg N_2O-N/(kg NH_3-N + kg NO_x-N)
1.571	=	Unit conversion from kg N_2O-N to kg N_2O	
$CH_{4\ B,i,j-CO2e}$	=	The reporting period CH_4 emissions for the baseline scenario from rice field i, for Monte Carlo run j	kg CO_2e/ha
$CH_{4\ B,i,j}$	=	Reporting period CH_4 emissions from rice field i for the baseline scenario from Monte Carlo run j	kg CH_4-C/ha
1.333	=	Unit conversion of C to CH_4	
$SOC_{B,i,j-CO2e}$	=	The reporting period soil organic carbon stored for the baseline scenario from rice field i, for Monte Carlo run j	kg CO_2e/ha
$SOC_{B,i,j}$	=	SOC content of rice field i on the last day of the reporting period for the baseline scenario from Monte Carlo run j	kg SOC-C/ha
3.667	=	Unit conversion of C to CO_2	
GWP_{N2O}	=	The GWP value for N_2O	
GWP_{CH4}	=	The GWP value for CH_4	

5.2.2.1 Baseline Scenarios Establishment

The Offset Project Operator or Authorized Project Designee must determine the baseline scenarios for each cropping parameter for each reporting period. The baseline scenarios must be established according to the following requirements:

(a) Soil data must be determined pursuant to subchapter 3.1(a)(6).

(b) Climate data must use data from the reporting period being considered as specified in subchapter 5.2(c)(2).

(c) Cropping data must be determined as specified in subchapters 5.2.2.1(d) through (l).

(d) Plant Date is the actual planting date for the reporting period being considered.

(e) Tillage Events are the actual tillage events for the reporting period being considered.

(f) Fertilization Events

(1) For California, the following applies:

(A) The baseline scenario fertilization event dates are determined by adding the average number of days from planting to the fertilization event for all the rice cultivation years in the baseline period to the planting date of the reporting period being considered; and

(B) The baseline scenario fertilization rates averaged by fertilization type for each event during the baseline period prior to offset project commencement.

(2) For the Mid-South, the DD50 model must be used to determine the baseline scenario fertilization events by using the emergence date for the reporting period being considered. The baseline fertilization rates are averaged by fertilization type for each event during the baseline period prior to offset project commencement.

(g) Flooding Date

(1) For California, the flooding date is determined by subtracting the average number of days from flooding to planting for all the rice cultivation years in the baseline period from the planting date for the reporting period being considered.

(2) For the Mid-South, the flooding date is the first flooding date for the reporting period being considered.

(h) Drain Date

(1) For California, the baseline scenario drain date is determined by adding the average number of days from planting to drain date for all the rice cultivation years in the baseline period to the planting date of the reporting period being considered.

(2) For the Mid-South, the DD50 model must be used to determine the baseline scenario drain date by using the emergence date for the reporting period being considered.

(i) Harvest Date

(1) For California, the baseline scenario harvest date is determined by adding the average number of days from planting to harvest during the baseline period to the planting date of the reporting period being considered.

(2) For the Mid-South, the DD50 model must be used to determine the baseline scenario harvest date by using the emergence date of the reporting period being considered.

(j) Winter Flooding Date: the actual winter flood date for the reporting period being considered will be used to determine the baseline scenario winter flood date.

(k) Winter Drain Date: the actual winter drain date for the reporting period being considered will be used to determine the baseline scenario winter drain date.

(l) Yield: the baseline scenario yield is determined by calculating the mean rice yields during all rice growing years in the baseline period.

(m) If any field is ineligible for a protocol practice, the relevant cropping parameters from the reporting period being considered will be used in place of the methods above.

(n) The baseline scenario for a rotation crop, winter crop, and fallow year is the same as the practices for the reporting period being considered.

(o) In cases of temporary emergency restrictions due to operational requirements of local water agencies, laws or regulations that mandate rice cultivation practices:

(1) These mandatory rice cultivation practices are not required to be used for establishing baseline scenarios; and

(2) Baseline must still contain at least two rice growing years even if it is required to go back more than five years.

5.2.3 Unadjusted Modeled Project GHG Emissions

(a) For each reporting period, the unadjusted project modeling must be equilibrated with at least 20 years, covering complete cropping cycles, including rotation crop(s) and fallow years, of historical data by repeating all parameters from the baseline period before the start of the crediting period four times. The 20-year spin up must include data for all crop and fallow years, not just rice crop years. The following data must be used.

(1) Soil data must be determined pursuant to subchapter 3.1(a)(6);

(2) Corresponding reporting period's climate data; and

(3) Baseline period's farming management practices.

(b) For each subsequent year of the crediting period, the unadjusted modeling must be equilibrated with at least 20 years of data from the baseline period as described in subchapter 5.2.2(c) and data from all preceding years in the crediting period.

(c) Unadjusted project GHG emissions for each rice field must be determined with the DNDC model based on the farming management practice parameters determined in subchapter 5.2(c), the soil parameters and climate profile parameters for the reporting period being considered. The following soil parameters will be selected for variation:

(1) Soil clay;

(2) Bulk density;

(3) SOC content; and

(4) pH value.

(d) The direct GHG emission parameters identified in box 5.3 are recovered from the DNDC runs.

Box 5.3. Recovered Project Parameters

Recovered Project Parameters			
$N_2O_{Dir,P,i,j}$	=	Project N_2O emissions from rice field i from Monte Carlo run j	kg N_2O-N/ha
$N_{Leach,P,i,j}$	=	Project nitrate leaching loss from rice field i from Monte Carlo run j	kg NO_3-N/ha
$N_{Vol,P,i,j}$	=	Project ammonia volatilization from rice field i from Monte Carlo run j	(kg NH_3-N + kg NOx-N)/ha
$CH_{4\ P,i,j}$	=	Project CH4 emissions from rice field i from Monte Carlo run j	kg CH_4-C/ha
$SOC_{P,i,j}$	=	Project soil organic carbon content from rice field i from Monte Carlo run j	Kg SOC-C/ha

(e) The unadjusted project GHG emissions from 1,000 runs of Monte Carlo simulation for field i must be calculated using equation 5.3.1 below. To use equation 5.3.1, the 1,000 runs must use the DNDC default range to vary the soil parameters listed in subchapter 5.2.3(c).

Equation 5.3.1 Calculating Unadjusted Project GHG Emissions from 1,000 Monte Carlo Runs

$$N_2O_{P,i,j-CO2e} = \{N_2O_{Dir,P,i,j} + (N_{Leach,P,i,j} \times EF_{Leach}) + (N_{Vol,P,i,j} \times EF_{Vol})\} \times 1.571 \times GWP_{N2O}$$

$$CH_{4\,P,i,j-CO2e} = CH_{4\,P,i,j} \times 1.333 \times GWP_{CH4}$$

$$SOC_{P,i,j-CO2e} = SOC_{P,i,j} \times 3.667$$

Where,			Units
i	=	Fields	-
j	=	Monte Carlo runs (1,000)	-
$N_2O_{P,i,j-CO2e}$	=	The reporting period direct and indirect N_2O emissions for the project scenario from rice field i for Monte Carlo run j	kg CO_2e/ha
$N_2O_{Dir,P,i,j}$	=	Project N_2O emissions from rice field i from Monte Carlo run j	kg N_2O-N/ha
$N_{Leach,P,i,j}$	=	Reporting period nitrate leaching loss from rice field i for the project scenario from Monte Carlo run j	kg NO_3-N/ha
EF_{Leach}	=	Emission factor for N_2O emissions from N leaching and runoff, equal to 0.0075	kg N_2O-N/kg NO_3-N
$N_{Vol,P,i,j}$	=	Reporting period ammonia volatilization and nitric oxide emissions from rice field i for the project scenario from Monte Carlo run j	(kg NH_3-N + kg NOx-N) /ha volatized
EF_{Vol}	=	Emissions factor for N_2O emissions from atmospheric deposition of N on soils and water surfaces and subsequent volatilization, equal to 0.01	kg N_2O-N/(kg NH_3-N + kg NO_x-N)
1.571	=	Unit conversion from kg N_2O-N to kg N_2O	
$CH_{4\,P,I,j-CO2e}$	=	The reporting period CH_4 emissions for the project scenario from rice field i, for Monte Carlo run j	kg CO_2e/ha
$CH_{4\,P,i,j}$	=	Reporting period CH_4 emissions from rice field i for the project scenario from Monte Carlo run j	kg CH_4-C/ha
1.333	=	Unit conversion of C to CH_4	
$SOC_{P,I,j-}$	=	The reporting period soil organic carbon stored for the project	kg CO_2e/ha

CO2e		scenario from rice field i, for Monte Carlo run j	
$SOC_{P,i,j}$	=	SOC content of rice field i on the last day of the reporting period for the project scenario from Monte Carlo run j	kg SOC-C/ha
3.667	=	Unit conversion of C to CO_2	
GWP_{N2O}	=	The GWP value for N_2O	
GWP_{CH4}	=	The GWP value for CH_4	

(f) The unadjusted project GHG emissions from sixteen runs of Monte Carlo simulation for field i must be calculated using equation 5.3.2 below. To use equation 5.3.2, the sixteen runs must comprise every possible combination of the minimum and maximum uncertainty values for each of the soil parameters shown in box 5.2.

Equation 5.3.2 Calculating Unadjusted Project GHG Emissions from 16 Monte Carlo Runs

$$\boldsymbol{N_2O_{P,i,j-CO2e} = \{N_2O_{Dir,P,i,j} + (N_{Leach,P,i,j} \times EF_{Leach}) + (N_{Vol,P,i,j} \times EF_{Vol})\} \times 1.571 \times GWP_{\ N2O}}$$

$$\boldsymbol{CH_{4_{P,i,j-CO2e}} = CH_{4_{P,i,j}} \times 1.333 \times GWP_{\ CH4}}$$

$$\boldsymbol{SOC_{P,i,j-CO2e} = SOC_{P,i,j} \times 3.667}$$

Where,			Units
i	=	Fields	-
j	=	Monte Carlo runs (16)	-
$N_2O_{P,i,j-CO2e}$	=	The reporting period direct and indirect N_2O emissions for the project scenario from rice field i for Monte Carlo run j	kg CO_2e/ha
$N_2O_{Dir,P,i,j}$	=	Project N_2O emissions from rice field i from Monte Carlo run j	kg N_2O-N/ha
$N_{Leach,P,i,j}$	=	Reporting period nitrate leaching loss from rice field i for the project scenario from Monte Carlo run j	kg NO_3-N/ha

EF_{Leach}	=	Emission factor for N_2O emissions from N leaching and runoff, equal to 0.0075	kg N_2O-N/kg NO_3-N
$N_{Vol,P,i,j}$	=	Reporting period ammonia volatilization and nitric oxide emissions from rice field i for the project scenario from Monte Carlo run j	(kg NH_3-N + kg NOx-N) /ha volatized
EF_{Vol}	=	Emissions factor for N_2O emissions from atmospheric deposition of N on soils and water surfaces and subsequent volatilization, equal to 0.01	kg N_2O-N/(kg NH_3-N + kg NO_x-N)
1.571	=	Unit conversion from kg N_2O-N to kg N_2O	
$CH_{4\ P,I,j\text{-}CO2e}$	=	The reporting period CH_4 emissions for the project scenario from rice field i, for Monte Carlo run j	kg CO_2e/ha
$CH_{4\ P,i,j}$	=	Reporting period CH_4 emissions from rice field i for the project scenario from Monte Carlo run j	kg CH_4-C/ha
1.333	=	Unit conversion of C to CH_4	
$SOC_{P,I,j\text{-}CO2e}$	=	The reporting period soil organic carbon stored for the project scenario from rice field i, for Monte Carlo run j	kg CO_2e/ha
$SOC_{P,i,j}$	=	SOC content of rice field i on the last day of the reporting period for the project scenario from Monte Carlo run j	kg SOC-C/ha
3.667	=	Unit conversion of C to CO_2	
0.0075	=	Emission factor for N_2O emissions from N leaching and runoff	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 volatilization	kg N_2O-N / (kg NH_3-N + kg NOx-N)
GWP_{N2O}	=	The GWP value for N_2O	
GWP_{CH4}	=	The GWP value for CH_4	

5.2.4 Calculating Modeled Primary Emission Reductions

(a) Total modeled primary source GHG emission reductions (PER) for a project from soil dynamics (SSR 1) during the reporting period must be calculated using Equation 5.4.

(b) Rice fields must be grouped by rice growing region.

(c) Total modeled primary source GHG emission reductions (PER_i) for each rice field from soil dynamics during the reporting period must be calculated using equation 5.4.1 if 1,000 runs of Monte Carlo simulation was used.

(1) $PER_{i,j}$ is calculated 1,000 times using the runs in the order output by DNDC (i.e., first baseline run is used with the first projects run… the nth baseline run is used with the nth project run).

(2) All $PER_{i,j}$ values are ranked numerically from lowest to highest.

(3) The 100th lowest value is selected for PER_i.

(d) Total modeled primary source GHG emission reductions (PER_i) for each rice field from soil dynamics during the reporting period must be calculated using equation 5.4.2 if 16 runs of Monte Carlo simulation was used.

(1) $PER_{i,j}$ is calculated 16 times using the runs in the order output by DNDC (i.e., first baseline run is used with the first projects run… the 16th baseline run is used with the 16th project run)

(2) The minimum value is selected for PER_i

Equation 5.4. Calculating Primary Source GHG Emissions Reductions for Each Project

$$\boldsymbol{PER} = \sum_{\boldsymbol{i}} (\boldsymbol{PER_i} \times \boldsymbol{A_i}) - (\mathbf{0.128} \times \sum_{\boldsymbol{i}} \boldsymbol{A_i})$$

Where,			Units
PER	=	Primary source GHG emission reductions over the entire project area, accounting for uncertainty deductions	$MTCO_2e$
With			
PER_i	=	Primary source GHG emission reductions for field *i*	$MTCO_2e/ha$
Ai	=	Area of field i in hectares	ha
0.128	=	DNDC structural uncertainty	$MTCO_2e/ha$

Equation 5.4.1 Calculating Primary Source GHG Emissions Reductions (PER_i) for Each Field (1,000 Runs of Monte Carlo Simulation)

$$PER_{\,i} = PER_{i,100}$$

With

$$PER_{\,i,j} = \frac{MIN\left[\left(N_2O_{B,i,j-CO2e} - N_2O_{P,i,j-CO2e}\right),0\right] + \left(CH_{4\,B,i,j-CO2e} - CH_{4\,P,i,j-CO2e}\right) - MAX\left[\left(SOC_{B,i,j-CO2e} - SOC_{P,i,j-CO2e}\right),0\right]}{1000}$$

Where,

			Units
PER_i	=	Primary effect GHG emission reductions for field ***i*** * (unadjusted for uncertainty)	$MTCO_2e$/ha
$PER_{i,j}$	=	Primary effect GHG emission reductions for field ***i*** * (unadjusted for uncertainty) for run j of Monte Carlo Simulation	$MTCO_2e$/ha
$N_2O_{B,i,j\text{-}CO2e}$	=	Baseline reporting period N_2O emissions for field *i* for run j of Monte Carlo Simulation as calculated in equation 5.2.1	kg CO_2e/ha
$N_2O_{P,i,j\text{-}CO2e}$	=	Project reporting period N_2O emissions for field ***I*** for run j of Monte Carlo Simulation as calculated in equation 5.3.1	kg CO_2e/ha
$CH_{4\ B,i,j\text{-}CO2e}$	=	Baseline reporting period CH_4 emissions for field ***I*** for run j of Monte Carlo Simulation as calculated in equation 5.2.1	kg CO_2e/ha
$CH_{4\ P,i,j\text{-}CO2e}$	=	Project reporting period CH_4 emissions for field ***I*** for run j of Monte Carlo Simulation as calculated in equation 5.3.1	kg CO_2e/ha
$SOC_{B,i,j\text{-}CO2e}$	=	SOC value on the last day of the baseline reporting period for field ***I*** for run j of Monte Carlo Simulation as calculated in equation 5.2.1	kg CO_2e/ha
$SOC_{P,i,j\text{-}CO2e}$	=	SOC value on the last day of the project reporting period for field ***I*** for run j of Monte Carlo Simulation as calculated in equation 5.3.1	kg CO_2e/ha
1000	=	Unit conversion kg to metric ton	kg/MT

Equation 5.4.2 Calculating Primary Source GHG Emissions Reductions (PER_i) for Each Field (16 Runs of Monte Carlo Simulation)

$$PER_i = MIN\left[PER_{i,1},\ PER_{i,2}, \ldots, PER_{i,16}\right]$$

With

$$PER_{i,j} = \frac{MIN\left[\left(N_2O_{B,i,j-CO2e} - N_2O_{P,i,j-CO2e}\right), 0\right] + \left(CH_{4_{B,i,j-CO2e}} - CH_{4_{P,i,j-CO2e}}\right) - MAX\left[\left(SOC_{B,i,j-CO2e} - SOC_{P,i,j-CO2e}\right), 0\right]}{1000}$$

Where,

			Units
PER_i	=	Primary effect GHG emission reductions for field ***i*** * (unadjusted for uncertainty)	$MTCO_2e/ha$
$PER_{i,j}$	=	Primary effect GHG emission reductions for field ***i*** * (unadjusted for uncertainty) for run j of Monte Carlo Simulation	$MTCO_2e/ha$
$N_2O_{B,i,j-CO2e}$	=	Baseline reporting period N_2O emissions for field ***i*** for run j of Monte Carlo Simulation as calculated in equation 5.2.2	kg CO_2e/ha
$N_2O_{P,i,j-CO2e}$	=	Project reporting period N_2O emissions for field ***I*** for run j of Monte Carlo Simulation as calculated in equation 5.3.2	kg CO_2e/ha
$CH_{4\ B,i,j-CO2e}$	=	Baseline reporting period CH_4 emissions for field ***I*** for run j of Monte Carlo Simulation as calculated in equation 5.2.2	kg CO_2e/ha
$CH_{4\ P,i,j-CO2e}$	=	Project reporting period CH_4 emissions for field ***I*** for run j of Monte Carlo Simulation as calculated in equation 5.3.2	kg CO_2e/ha
$SOC_{B,i,j-CO2e}$	=	SOC value on the last day of the baseline reporting period for field ***I*** for run j of Monte Carlo Simulation as calculated in equation 5.2.2	kg CO_2e/ha
$SOC_{P,i,j-CO2e}$	=	SOC value on the last day of the project reporting period for field ***I*** for run j of Monte Carlo Simulation as calculated in equation 5.3.2	kg CO_2e/ha
1000	=	Unit conversion kg to metric ton	kg/MT

5.3 Calculating Secondary Emissions

(a) The total secondary emissions for a project must be quantified using equation 5.6.

(b) Any increased GHG emissions as a result of implementing a project must be debited from total project primary source emission reductions.

(c) Any decreased GHG emissions as a result of implementing a project is not eligible for crediting and the total secondary source emission increase for the project must be set to zero.

Equation 5.6. Total Secondary Source GHG Emissions Increases for Each Project

$$\boldsymbol{SE = MAX\left[\sum_{i}(SE_{FF,i} + SE_{BR,i}), 0\right]}$$

Where,

			Units
SE	=	Total secondary source emission increase for each project	$MTCO_2e$
$SE_{FF,i}$	=	Total secondary source GHG emissions from fossil fuel combustion for total fields i, as calculated in Equations 5.7 through 5.9.	$MTCO_2e$
$SE_{BR,i}$	=	Total secondary source GHG emissions from on-site rice straw open burning for total fields i, as calculated in equation 5.10	$MTCO_2e$

5.3.1 Calculating Secondary Source Emissions From Fossil Fuel Combustion for Each Field

(a) Secondary source GHG emission increases from fossil fuel combustion ($SE_{FF,i}$) must be calculated using equation 5.7 if baseline scenario and project fuel consumption is available. The average baseline scenario fuel consumption ($FF_{B,k,i}$) is determined by averaging fuel consumption from all the rice cultivation years in the in the baseline period (option 1).

(b) If fuel consumption data is unavailable, secondary source GHG emissions increases from fossil fuel combustion ($SE_{FF,i}$) must be calculated using either equation 5.8 (option 2) or equations 5.8 and 5.9 (option 3).

(1) The average baseline scenario time required ($t_{B,l,i}$) and equipment horsepower ($HP_{B,i,i}$) are determined by averaging the time required and equipment horsepower from all the rice cultivation years in the in the baseline period .

(2) If baseline scenario equipment horsepower ($HP_{B,i,i}$) is not available, then the highest equipment horsepower from the current reporting period must be used.

(3) If baseline scenario time required ($t_{B,l,,i}$) or project time required ($t_{P,l,i}$) are not available, then they both must be estimated using equation 5.9.

Equation 5.7. Secondary GHG Emissions from Cultivation Equipment: Option 1 (fuel based)

$$SE_{FF,i} = \frac{\sum_i \sum_k \left(\left(FF_{P,k,i} - FF_{B,k,i} \right) \times EF_{FF,k} \right)}{1000}$$

Where, Units

$SE_{FF,i}$	=	Secondary emissions from a change in cultivation equipment on field *i*	MT CO_2e
$FF_{P,k,i}$	=	Fossil fuel consumption for field *i* during the reporting period, by fuel type *k*	gallons
$FF_{B,k,i}$	=	Average baseline scenario fossil fuel consumption for field *i*, by fuel type *k*	gallons
$EF_{FF,k}$	=	Fuel-specific emission factor from Appendix C	kg CO_2/gallon fossil fuel
k	=	Fuel type	
1000	=	Kilograms per metric ton	kg CO_2/MT CO_2

Equation 5.8. Secondary GHG Emissions from Cultivation Equipment: Option 2 (Time Based)

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

Where, Units

$SE_{FF,i}$	=	Secondary emissions from a change in cultivation equipment on field *i*	MT CO_2
$EF_{HP\text{-}hr,P,l,i}$	=	Emission factor for project operation *l* on field *i*. Default value is 1311 for gasoline-fueled operations and 904 for diesel-fueled operations	g CO_2e/HP-hr
$HP_{P,l,i}$	=	Equipment horsepower for project operation *l* on field *i*	HP
$t_{P,l,i}$	=	Time required to perform project operation *l* on field *i*	hr/field

$EF_{HP\text{-}hr,B,l,i}$	=	Default emission factor for baseline operation *k* on field *f* Default value is 1311 for gasoline-fueled operations and 904 for diesel-fueled operations	g CO_2e/HP-hr
$HP_{B,l,i}$	=	Equipment horsepower for baseline operation *l* on field *i*	HP
$t_{B,l,i}$	=	Time required to perform baseline operation *l* on field *i*	hr/field
l	=	Project operation	
10^{-6}	=	G per metric ton	

Equation 5.9. Secondary GHG Emissions from Cultivation Equipment: Option 3 (Field Dimension Based)

$$\boldsymbol{t_{(B\ or\ P),l,i}} = \frac{\boldsymbol{A_i}}{(\boldsymbol{width} \times \boldsymbol{speed} \times \mathbf{1000})} \times \mathbf{10,000}$$

Where,			Units
$T_{(B\ or\ P),l,i}$	=	Time requirement for field operation *l* on field *i*	hr
10,000	=	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_i	=	Size of field *i*	ha

5.3.2. Calculating Secondary Source GHG Emissions from On-Site Rice Straw Open Burning for Each Field

Secondary source GHG emission increases from rice straw management practices must be calculated using equation 5.10.

Equation 5.10. Secondary GHG Emissions from Rice Straw Open Burning

$$SE_{BR,i} = \frac{\sum_i\left(Area_{BR,P,i} \times (EF_{BR,CH4} + EF_{BR,CO2})\right) - \sum_i\left(Area_{BR,B,i} \times (EF_{BR,CH4} + EF_{BR,CO2})\right)}{1000}$$

Where,			Units
$SE_{BR,i}$	=	Project emission from rice straw open burning	MT CO_2e
$Area_{BR,P,i}$	=	Area of rice straw burned on field i for the project scenario	ha
$Area_{BR,B,i}$	=	Average area of rice straw burned on field i for the baseline period	ha
$EF_{BR,\ CH4}$	=	$10.72 \times GWP_{CH4}$ Methane emission factor for rice straw open burning	$KgCO_2e/ha$
$EF_{BR,\ CO2}$	=	26.8 Carbon dioxide emission factor for straw open burning	$KgCO_2e/ha$
1000	=	Kilograms per metric ton	kg CO_2/MT CO_2

5.4 Conversion Factors

For the purposes of this protocol, the following conversion factors apply.

(a) 1 hectare (ha) equals 2.4711 acres.

(b) 1 pound (lb) equals 0.4536 kilogram (Kg).

(c) 1 foot (ft) equals 0.3048 meter.

Chapter 6. Monitoring – Quantification Methodology

6.1 General Project Monitoring Requirements

The Offset Project Operator or Authorized Project Designee is responsible for monitoring all parameters prescribed in Table 6.1.

Table 6.1. Monitoring Parameters Quantification Methodology

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	User defined
	Atmospheric background NH_3 concentration	μg N/m^3	r	Once per crediting period	DNDC default
	Atmospheric background CO_2 concentration	ppm	r	Once per crediting period	400 ppm
	Daily precipitation	cm	m	Daily	See subchapter 5.2(c)(2)
	Daily maximum temperature	°C	m	Daily	See subchapter 5.2(c)(2)
	Daily minimum temperature	°C	m	Daily	See subchapter 5.2(c)(2)
	N concentration in rainfall	mg N/l	r	Once per crediting period	California: 0.66 MS Delta:1.03 Gulf Coast of LA: 0.91
Soils	Land-use type	type	m	Once per crediting period	User defined
	Clay content	0-1	m/r	Once per crediting	See subchapter 5.2(c)(1)

Parameter	Description	Data Unit	Calculated (c) Measured (m) Reference(r) Operating Records (o)	Measurement Frequency	Comment
				period*	
	Bulk density	g/cm^3	m/r	Once per crediting period*	See subchapter 5.2(c)(1)
	Soil pH	value	m/r	Once per crediting period*	See subchapter 5.2(c)(1)
	SOC at surface soil	kg C/kg	m/r	Once per crediting period*	See subchapter 5.2(c)(1)
	Soil texture	type	m/r	Once per crediting period*	See subchapter 5.2(c)(1)
Crop	Crop type	type	o	Per reporting period	OPO records
	Planting date**	date	o	Per reporting period	OPO records
	Harvest date**	date	o	Per reporting period	OPO records
	C/N ratio of the grain	ratio	m/r	Once per variety	Table B.1
	C/N ratio of the leaf	ratio	m/r	Once per variety	Table B.1
	C/N ratio of the shoot	ratio	m/r	Once per variety	Table B.1
	C/N ratio of the root tissue	ratio	m/r	Once per variety	Table B.1
	Fraction of leaves + stem left in field	0-1	m	Per reporting period	OPO records

Parameter	Description	Data Unit	Calculated (c) Measured (m) Reference(r) Operating Records (o)	Measurement Frequency	Comment
	after harvest				
	Maximum biomass	kg dry matter/ha	c/m	Per reporting period	OPO records Appendix B
	Cover crop	0/1	r	Once per variety	Table B.1
	Perennial crop	0/1	r	Once per variety	Table B.1
	Biomass leaf fraction	0-1	m/r	Once per variety	Table B.1
	Biomass grain fraction	0-1	m/r	Once per variety	Table B.1
	Biomass shoot fraction	0-1	m/r	Once per variety	Table B.1
	Biomass root fraction	0-1	m/r	Once per variety	Table B.1
	Thermal degree days (TDD)	^{o}C	c/r	Once per variety	Table B.1 Appendix B
	Water demand	g H_2O/g dry weight	m/r	Once per variety	Table B.1
	Optimum temperature	^{o}C	m/r	Once per variety	Table B.1
	N fixation index	total plant N content/ N from soil	m/r	Once per variety	Table B.1
	Vascularity	0-1	m/r	Once per variety	Table B.1
Tillage	Number of tillage	number	o	Per reporting	OPO records

Parameter	Description	Data Unit	Calculated (c) Measured (m) Reference(r) Operating Records (o)	Measurement Frequency	Comment
	events**			period	
	Date of tillage events**	date	o	Per reporting period	OPO records
	Depth of tillage events**	cm (select from 7 default depths in DNDC)	o	Per reporting period	OPO records
Use of synthetic fertilizer	Number of fertilizer applications**	number	o	Per reporting period	OPO records
	Date of each fertilizer application**	date	o	Per reporting period	OPO records
	Application method**	surface / injection	o	Per reporting period	OPO records
	Type of fertilizer**	Type	o	Per reporting period	OPO records
	Fertilizer application rate**	kg N/ha	o, C	Per reporting period	OPO records (field average if using variable rate applications)
Manure amendment[4] (if used)	Number of organic applications per year**	number	o	Per reporting period	OPO records
	Date of application**	date	o	Per reporting period	OPO records

[4] 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.

Parameter	Description	Data Unit	Calculated (c) Measured (m) Reference(r) Operating Records (o)	Measurement Frequency	Comment
	Type of organic amendment**	type	o	Per reporting period	OPO records
	Application rate**	kg C/ha	o	Per reporting period	OPO records
	Amendment C/N ratio**	ratio	o	Per reporting period	DNDC defaults
Irrigation	Number of irrigation events**	number	o	Per reporting period	OPO records
	Date of irrigation events**	date	o	Per reporting period	OPO records
	Irrigation type**	Must use the 'flood' default type	o	Per reporting period	OPO records
	Irrigation application rate**	cm	o	Per reporting period	OPO records
Flooding and Draining	Date of flood-up or drain for growing season**	date	o	Per flooding/ draining event	OPO records
	Date of drain for crop harvest**	date	o	Per draining event	OPO records
	Date of flood-up for winter flooding (if applicable)**	date	o	Per flooding event	OPO records
	Date of drain for winter flooding (if applicable)**	date	o	Per draining event	OPO records
Fuel usage	For Equation 5.7: fossil fuel consumption	Quantity of fossil fuel Fuel type	m,o	Per reporting period (aggregated by event	OPO records

Parameter	Description	Data Unit	Calculated (c) Measured (m) Reference(r) Operating Records (o)	Measurement Frequency	Comment
				consumption)	
	For Equation 5.8	Fuel type Equipment horsepower Equipment operation time	o	Per reporting period (aggregated by event consumption)	
	For Equation 5.9	Area of field Application width Average ground speed	m,o	Per reporting period (aggregated by event consumption)	
Crop residue management parameters	Crop residue management approach and fraction of crop residue left in the field.	Approach and fraction	o	Per reporting period, event based	OPO records

Note: *Soil parameters must be recorded again in the event of soil movement, soil replacement, or in the event of natural disasters that alter the original soil characteristics. Natural disasters may include earthquakes, mudslide, flood, etc.

** Parameters must also be monitored for winter crops and rotation crops.

6.2 General Document Retention

(a) The Offset Project Operator or Authorized Project Designee is required to keep all documentation and information outlined in the Regulation and this protocol. Record retention requirements are set forth in section 95976 of the Regulation.

(b) Information that must be retained by the Offset Project Operator or Authorized Project Designee includes:

(1) All data inputs for the calculation of the project baseline scenario emissions and project emission reductions including:

(A) DNDC inputs for farming management information and soil and climate profile parameters;

(B) Recovered parameters from DNDC runs;

(C) Historical data used to determine baseline scenarios;

(D) Fuel purchase records;

(E) Documentation of farm equipment purchased or leased;

(F) Crop residue management records;

(G) Documentation of water usage including deliveries, drainage, and pumping;

(H) Documentation of fertilizer, herbicide, and pesticide acquisition and application;

(I) Documentation of types and amount of rice seed purchased;

(J) Documentation of rice seed application rate; and

(K) Documentation of any services related to project activities.

(2) Emission reduction calculations and materials used for emission reduction calculations;

(3) Land ownership and lease documents, if applicable, and air, water, herbicide, pesticide, and land use permits;

(4) Notices of Violation (NOVs), and any administrative or legal consent orders related to project activities dating back at least three years prior to offset project commencement date and for each year within the project's crediting period;

(5) Documentation of field boundaries throughout the project life; and

(6) Every other parameter specified in table 6.1.

6.2.1 Documentation for All Activities

(a) The Offset Project Operator or Authorized Project Designee must document to the satisfaction of verification bodies, the Offset Project Registry and ARB that the project activities claimed actually took place.

(b) In addition to the documentation required in subchapter 6.2 the following types information can be maintained by the Offset Project Operator or Authorized Project Designee to help demonstrate a project activity occurred:

  (1) A digital photo or photographs for each field taken from various vantage points clearly establishing project activities. Each photograph should be taken using a device that has geotagging feature to include date and geocoordinates in the metadata of the photograph;

  (2) Satellite imagery with spatial and temporal resolution adequate to clearly establish project activities; or

  (3) Video or photographic communication with the verification body pursuant to subchapter 8.1(i) during project activities.

(c) Other information not identified here can be used to document project activities.

(d) The information identified here may not be sufficient to document a project activity alone.

6.2.2 Documentation for Early Drainage in Preparation for Harvest Activities

For each rice maturity sample taken pursuant to subchapter 2.2(b)(1) the total number of panicles, the number of heading panicles or panicles with at least one yellow hull and the number of panicles not heading or panicles without any yellow hull must be documented.

6.2.3 Documentation for Alternate Wetting and Drying Activities

(a) For each round of wetting and drying, soil moisture readings must be taken following the requirements specified in subchapter 2.3(c) or Appendix D. The following parameters must be monitored and documented for each participating field:

  (1) A diagram that includes dimensions and shows where samples are taken in a field;

  (2) The date when the field was flooded or received water;

(3) The date when the soil moisture readings were taken; and

(4) The field grading status.

(b) The standard procedures of taking soil moisture reading and information of equipment used as specified in subchapter 2.3(c)(5)(F) or Appendix D must be retained.

6.2.4 Documentation for Fallow Year, Rotation Crop, and Winter Crop

(a) For a fallow year, proof from federal, state, regional, or local Agricultural Commissioner, agricultural advisor, or equivalent agency or quasi-agency must be shown to demonstrate a fallow year.

(b) For a rotation crop or winter crop, the following must be documented:

(1) Crop type;

(2) Planting and harvest dates;

(3) Irrigation dates;

(4) Flooding dates;

(5) Draining dates;

(6) Tillage dates and methods;

(7) Fertilizer application dates, quantity, and compositions; and

(8) Fraction of crop residue left in the field after harvest.

Chapter 7. Reporting

7.1 General Project Listing Requirements

(a) Listing information must be submitted by the Offset Project Operator or Authorized Project Designee no later than the date on which the Offset Project Operator or Authorized Project Designee submits the first Offset Project Data Report.

(b) The Offset Project Operator or Authorized Project Designee must submit the information required by section 95975 of the Regulation, in addition to the following information to list a Rice Cultivation Compliance Offset Project:

(1) Offset project name;

(2) Rice cultivation activity types (i.e., dry seeding activity, early drainage in preparation for harvest activity, and/or alternate wetting and drying activity) for each field;

(3) Contact information, including name, phone number, mailing address, physical address (if different from mailing address), and E-mail address for the:

(A) Offset Project Operator; and

(B) Authorized Project Designee (if applicable);

(4) CITSS General Account Number for the:

(A) Offset Project Operator; and

(B) Authorized Project Designee (if applicable);

(5) Contact information, including name, phone number, mailing address, physical address (if different from mailing address), and e-mail address for:

(A) Person submitting the listing information; and

(B) Technical consultants;

(6) Date of listing information submission;

(7) A description of the field ownership and operational structures;

(8) Documentation (e.g., title report, lease, etc.) showing the Offset Project Operator’s legal authority to implement the offset project;

(9) Physical address, latitude and longitude coordinates and parcel number recorded in the County Assessor's Office (or equivalent) for each field;

(10) The Rice Growing Region(s) where the project is located;

(11) Number of fields and size (hectares) and dimensions of each field;

(12) A diagram or map that illustrates the location and geocoordinates of each field;

(13) Crop cycle pattern for each field during the baseline period;

(14) Indicate if the project occurs on private or public lands and further specify if the project occurs on any of the following categories of land:

(A) Land that is owned by, or subject to an ownership or possessory interest of a Tribe;

(B) Land that is “Indian lands” of a Tribe, as defined by 25 U.S.C. §81(a)(1); or

(C) Land that is owned by any person, entity, or Tribe, within the external borders of such Indian lands; and

(D) If the project is located on one of the above categories of land, a description and copies of documentation demonstrating that the land is owned by (or subject to an ownership or possessory interest of) a tribe or private entities.

7.2 Offset Project Data Report

(a) Offset Project Operators or Authorized Project Designees must submit the following information in addition to the information required by section 95976 of the Regulation:

(1) Offset project name and identification numbers;

(2) Rice cultivation activity types employed (i.e., dry seeding activity, early drainage in preparation for harvest activity, and/or alternate wetting and drying activity) for each rice field;

(3) Contact information, including name, phone number, mailing address, physical address (if different from mailing address), and E-mail address for the:

(A) Offset Project Operator; and

(B) Authorized Project Designee (if applicable);

(4) CITSS ID number for the:

(A) Offset Project Operator; and

(B) Authorized Project Designee (if applicable);

(5) Contact information, including name, phone number, mailing address, physical address (if different from mailing address), and E-mail address for:

(A) Person submitting the listing information; and

(B) Technical consultants;

(6) Date of Offset Project Data Report submission;

(7) Reporting period;

(8) Offset project commencement date;

(9) Statement as to whether all the information submitted for project listing is still accurate. If not, provide updates to the relevant listing information;

(10) Statement as to whether the project has met all local, state, and federal regulatory requirements during the reporting period. If not, an explanation of the non-compliance must be provided;

(11) Unadjusted baseline scenario primary source GHG emissions during the reporting period ($N_2O_{B,i}$, $CH_{4\ B,i}$, $SOC_{B,i}$) for each field following the requirements of Chapter 5 and number of runs selected for quantification;

(12) Unadjusted project primary source GHG emissions during the reporting period ($N_2O_{P,i}$, $CH_{4\ P,i}$, $SOC_{P,i}$) for each field following the requirements of Chapter 5 and number of runs selected for quantification;

(13) Primary source project emissions reductions (PER) for each field during the reporting period;

(14) Total secondary source GHG emissions from fossil fuel combustion ($SE_{FF,i}$) for each field during the reporting period following the requirements of Chapter 5;

(15) Total secondary source GHG emissions increase (SE_{RM}) from rice straw burning for each field during the reporting period following the requirements of Chapter 5;

(16) Total emission reductions (ER) from each field and the entire project area, respectively, during the reporting period following the requirements of Chapter 5;

(17) Project baseline scenario parameters for each field;

(18) Whether there was a rotation crop, winter crop, or fallow year. For winter crop and rotation crop, identify the dates for planting, irrigation, fertilization, harvest, and crop residue management and fraction of crop residue left in the field after harvest; and

(19) If there is an event of an anthropogenic or natural soil alternation or movement, the event date and new soil characteristics have to be documented.

Chapter 8. Verification Requirements

8.1 General Verification Requirements

(a) Every Offset Project Data Report is subject to regulatory verification as set forth in section 95977 of the Regulation by an ARB-accredited offset verification body.

(b) A verification of offset projects must be performed on a reporting period rolling basis and cover the reporting period for which the most recent Offset Project Data Report was submitted except when:

(1) A project produces less than 25,000 metric tons of CO_2e of GHG emission reductions in a reporting period, the Offset Project operator or Authorized Project Designee may choose to perform verification that covers two consecutive reporting periods even if the subsequent reporting period is greater than or equal to 25,000 metric tons of CO_2e; and

(2) A deferred verification, as specified in 95977(b) of the Regulation, may cover up to three reporting periods including at least one reporting period that results in an Offset Project Data Report with zero GHG emission reductions; and

(c) Each fallow year, rotation crop year, and winter crop must be verified for the activities specified in table 6.1 and data entered into the DNDC model.

(d) The Offset Project Data Report must receive a positive or qualified positive offset verification statement to be issued ARB or registry offset credits.

(e) Each verification team must include an agronomic expert with one of the following qualifications:

(1) An agronomist with at least five years of direct professional experience in rice cultivation; or

(2) A local or state agricultural cooperative rice farming advisor.

(f) The agronomic expert on the verification team must evaluate the fifty-percent heading or the one yellow hull requirement in subchapter 2.2(b) and the suitability requirements for ratooning as specified in section 3.10. The detailed agronomic expert's assessment must be included in the Offset Verification Report.

(g) Verification must be conducted for the first reporting period upon the change of the Offset Project Operator.

(h) The Offset Project Operator or Authorized Project Designee may contract with a verification body prior to the end of the reporting period. However, no verification services may be performed prior to the preliminary OPDR being submitted except for witnessing project activities.

Appendix A. Management Records for Baseline Period

For a project to be eligible, the following information from the baseline period must be available upon project listing and retained for 15 years from the project commencement date:

(a) General information for each participating field:

(1) Field geographic coordinates, county, and state for each field, and parcel number;

(2) Flooding[5] and drainage[6] dates (during the growing season and during post-harvest period);

(3) Begin and end date of harvesting on the field;

(4) Post-harvesting residue management (e.g., burning, incorporation or baling) description and dates;

(5) Amount of herbicides applied for the baseline period cultivation cycle and the project scenario cultivation cycle;[7]

(6) Fertilization types, amounts, rate, and application methods and dates for each application;[8]

(7) Estimate of crop residue remaining in the field, depending on the post-harvest residue management practice indicated above;

(8) Moisture content for milled rice from the year with maximum observed rice yield; and

(9) Dates and depth of all tillage events for preparing the fields for planting and post-harvest residue management.

(b) Additional information for dry seeding projects:

(1) Planting preparation description and date;

(2) Planting date and method; and

(3) The date a field is fully flooded after dry seeding.

(c) Additional information for early drainage in preparation for harvest projects:

[5] For each participating field, the flood date shall be the date that the flooding starts.
[6] For each participating field, the drainage date shall be the date that the drainage starts or soil is exposed without standing water, while the soil is still saturated, if there is no overt action that starts drainage.
[7] Amounts of herbicide used in the baseline scenario cultivation cycle do not need to be verified.
[8] The fertilizer type must correctly reflect its ammonium-nitrate composition.

(d) Additional information for alternate wetting and drying:

(1) The date(s) that water board(s) were pulled from the weirs or the flooding of the field was stopped; and

(2) Soil moisture reading date, number of readings, and the results of the readings.

Appendix B. Crop Calibration Methodology - Quantification Methodology

Certain rice crop parameters must be calibrated through DNDC model simulations. This multi-step process involves setting the crop's duration to maturity in cumulative thermal degree days (TDD), and maximum biomass (BM_{max}). Parameters for the historic period are based on data from the historic period and first reporting period and once calibrated are fixed values for the duration of the project. Starting with the first reporting period, parameters are calibrated for each reporting period using data from the reporting period. Parameters are determined as follows:

Step 1 – Selecting the Right Parameter Set for the Variety Used

1. Input the default crop parameters using the appropriate rice variety values from the table B-1.

Table B.1. DNDC Input Parameters Default Values for Crop Calibration

DNDC Input Parameters	California	Mid-South	
	All Non-wild Rice	MRD[9]	LGC[10]
Cover_Crop	0	0	0
Perennial_Crop	0	0	0
Leaf_fraction	0.21	0.22	0.25
Grain_fraction	0.48	0.48	0.41
Shoot_fraction	0.22	0.23	0.25
Root_fraction	0.09	0.07	0.09
Leaf_CN	85	85	85
Grain_CN	45	45	45
Shoot_CN	85	85	85
Root_CN	85	85	85
Water_requirement	508	508	508

[9] Mississippi River Delta Rice Growing Region
[10] Louisiana Gulf Coast Rice Growing Region.

DNDC Input Parameters	California	Mid-South	
	All Non-wild Rice	MRD[9]	LGC[10]
Optimum_temp	22	22	25
N_fixation	1.05	1.05	1.05
Vascularity	1	1	1
BM_{max} (default)	4082	3878	4609

Step 2 – Determining the Thermal Degree Days

1. Compile daily weather data for the baseline period and the reporting period.
2. Calculate daily mean temperature from plant date to 7 days prior to harvest date (inclusive using equation B.1).

Equation B.1. Daily Mean Temperature

$$T_{mean,day} = \frac{T_{max,day} + T_{min,day}}{2}$$

Where,			Units
$T_{mean,day}$	=	Daily mean temperature	°C
$T_{max,day}$	=	Daily maximum temperature	°C
$T_{min,day}$	=	Daily minimum temperature	°C

3. If for any day:
   a) $T_{mean,day} \geq 6°C$ then $TDD_{day} = T_{mean,day}$; or
   b) $T_{mean,day} < 6°C$ then $TDD_{day} = 0.0$
4. Calculate the cumulative TDD for the rice crop for each rice growing season ($TDD_{cumulative}$) as the sum of TDD_{day} from plant date to the date 7 days prior to harvest date (inclusive) using equation B.2.

Equation B.2. Cumulative Thermal Degree Days

$$TDD_{cumulative} = \sum_{day} TDD_{day}$$

Where,			Units
$TDD_{cumulative}$	=	Cumulative TDD from plant date to 7 days prior to harvest (inclusive)	°C
TDD_{day}	=	Daily TDD determined from step 2.3	°C
day	=	Days from planting to 7 days prior to harvest (inclusive)	

5. The final TDD parameter for the historical period is the minimum $TDD_{cumulative}$ from the set of historical years when rice was planted. The TDD parameter for any reporting period is the calculated $TDD_{cumulative}$ for that reporting period.

Step 3 – Historical Maximum Biomass

The following steps outline the method by which the historical maximum biomass parameter can be calculated:

1. Compile reported rice yield for all rice growing years in the historical period.
2. Convert reported yield to kg C/ha using conversion factors in table B.2.

Table B.2. Yield Conversion Factors

Reported Units	Conversion Factor
lb/acre	0.386 kg C acre/ha lb
cwt/acre	38.557 kg C acre/ha cwt
bu/acre	17.351 kg C acre/ha bu

3. Select the maximum yield from the historical period ($yield_{max}$).
4. Calculate initial maximum biomass parameter as described in equation B.3.

Equation B.3. Initial Maximum Biomass

$$BM_{max,init} = \frac{yield_{max}}{frac_{grain}}$$

Where,	Units

$BM_{max,init}$	=	Initial maximum biomass parameter for the historical period	kg C/ha
$yield_{max}$	=	Maximum yield from the historical period determined in step 3.3	kg C/ha
$frac_{grain}$	=	Grain_fraction from table B.1	

5. Simulate the rice field per subchapters 5.2.3(a) and 5.2.3(b) using the historical TDD parameter from step 2, $BM_{max\ init}$ from equation B.3, and area-weighted mean soil attribute values and management data from all years.
6. Calculate the percent relative RMSE from the reported and simulated rice yield data from all rice growing years in the historical period using equation B.4.

Equation B.4. Relative RMSE Percent

$$\boldsymbol{RMSE_{rel}} = \frac{\sqrt{\frac{\sum_{i=1}^{n}(\boldsymbol{yield_{actual,i}} - \boldsymbol{yield_{sim,i}})^2}{\boldsymbol{n}}}}{\boldsymbol{yield_{actual,mean}}} \times \mathbf{100}\%$$

Where,			Units
$RMSE_{rel}$	=	Percent relative RMSE from the reported and simulated data	percent
$yield_{actual,i}$	=	Actual rice yield from year i of historical period	kg C/ha
$yield_{sim,i}$	=	DNDC calculated rice yield from year i of historical period	kg C/ha
$yield_{actual,mean}$	=	Average actual rice yield from all yeas in the historical period	kg C/ha
i	=	years	
n	=	Number of rice growing years in the historical period	

a) If $RMSE_{rel}$ is <10%, accept all parameters; or

b) If $RMSE_{rel}$ is ≥10%, re-simulate after adjusting BM_{max} as follows:

i. If mean $yield_{sim,i}$ is < mean $yield_{actual,i}$, increase BM_{max} by 5%; or

ii. If mean $yield_{sim}$ is ≥ mean $yield_{actual,i}$, decrease BM_{max} by 5%.

7. If, by resimulating ten times, $RMSE_{rel}$ does not fall <10%, use the smaller of the following:

a) $BM_{max,\ init}$; or

b) Default BM_{max} for the appropriate rice growing region in table B.1.

Step 4 – Reporting Period Maximum Biomass

1. Compile yield data for the reporting year being calibrated and convert to kg C/ha ($yield_{rp}$) using table B.2.
2. Calculate reporting period initial maximum biomass parameter as described in equation B.5.

Equation B.5. Initial Maximum Biomass

$$BM_{max,rp,init} = \frac{yield_{rp}}{frac_{grain}}$$

Where,

			Units
$BM_{max,rp,init}$	=	Initial maximum biomass parameter for the reporting period	kg C/ha
$yield_{rp}$	=	Yield from the reporting period	kg C/ha
$frac_{grain}$	=	Grain_fraction from table B.1	

3. Simulate the rice field as per subchapters 5.2.3(a) and 5.2.3(b) using the reporting period TDD parameter from step 2, $BM_{max,rp,init}$ from equation B.5 and area-weighted mean soil attribute values and management data from the reporting period.
4. Calculate the yield difference using equation B.6.

Equation B.6. Yield Difference

$$yield_{diff} = \frac{|yield_{rp} - yield_{sim}|}{yield_{rp}} \times 100\%$$

Where,

			Units
$yield_{diff}$	=	Percent relative yield difference	percent
$yield_{rp}$	=	Yield from the reporting period	kg C/ha
$yield_{sim}$	=	DNDC calculated rice yield from the reporting period	kg C/ha

a) If $yield_{diff}$ <10%, accept all parameters; or

b) If $yield_{diff}$ ≥10%, resimulate by adjusting BM_{max} as follows:

i. If $yield_{sim}$ is < $yield_{rep}$, increase BM_{max} by 5%; or

ii. If $yield_{sim}$ is >= $yield_{rep}$, decrease BM_{max} by 5%.

5. If, by resimulating ten times, $yield_{diff}$ does not arrive at a value <10%, use the smallest BM_{max} that achieves the minimum $yield_{diff}$.

Appendix C. Emission Factors – Quantification Methodology

An Offset Project Operator or Authorized Project Designee must use the emission factors in Table C-1 for fuel combustion activities, except that for projects located in the California Rice Growing Region, the emission factors for fossil fuel combustion are zero.

Table C.1. Emission Factors for Fuel Use

Fuel Type	Default High Heat Value	Default CO_2 Emission Factor	Default CO_2 Emission Factor
Coal and Coke	**MMBtu / short ton**	**kg CO_2 / MMBtu**	**kg CO_2 / short ton**
Anthracite	25.09	103.54	2597.819
Bituminous	24.93	93.40	2328.462
Subbituminous	17.25	97.02	1673.595
Lignite	14.21	96.36	1369.276
Coke	24.80	102.04	2530.592
Mixed (Commercial sector)	21.39	95.26	2037.611
Mixed (Industrial coking)	26.28	93.65	2461.122
Mixed (Electric Power sector)	19.73	94.38	1862.117
Natural Gas	**MMBtu / scf**	**kg CO_2 / MMBtu**	**kg CO_2 / scf**
(Weighted U.S. Average)	1.028×10^{-3}	53.02	0.055
Petroleum Products	**MMBtu / gallon**	**kg CO_2 / MMBtu**	**kg CO_2 / gallon**
Distillate Fuel Oil No. 1	0.139	73.25	10.182
Distillate Fuel Oil No. 2	0.138	73.96	10.206
Distillate Fuel Oil No. 4	0.146	75.04	10.956
Distillate Fuel Oil No. 5	0.140	72.93	10.210
Residual Fuel Oil No. 6	0.150	75.10	11.265
Used Oil	0.135	74.00	9.990
Kerosene	0.135	75.20	10.152
Liquefied petroleum gases (LPG)	0.092	62.98	5.794
Propane	0.091	61.46	5.593
Propylene	0.091	65.95	6.001
Ethane	0.069	62.64	4.322
Ethanol	0.084	68.44	5.749
Ethylene	0.100	67.43	6.743
Isobutane	0.097	64.91	6.296
Isobutylene	0.103	67.74	6.977
Butane	0.101	65.15	6.580

Fuel Type	Default High Heat Value	Default CO_2 Emission Factor	Default CO_2 Emission Factor
Coal and Coke	**MMBtu / short ton**	**kg CO_2 / MMBtu**	**kg CO_2 / short ton**
Butylene	0.103	67.73	6.976
Naphtha (<401 deg F)	0.125	68.02	8.503
Natural Gasoline	0.110	66.83	7.351
Other Oil (>401 deg F)	0.139	76.22	10.595
Pentanes Plus	0.110	70.02	7.702
Petrochemical Feedstocks	0.129	70.97	9.155
Petroleum Coke	0.143	102.41	14.645
Special Naphtha	0.125	72.34	9.043
Unfinished Oils	0.139	74.49	10.354
Heavy Gas Oils	0.148	74.92	11.088
Lubricants	0.144	74.27	10.695
Motor Gasoline	0.125	70.22	8.778
Aviation Gasoline	0.120	69.25	8.310
Kerosene-Type Jet Fuel	0.135	72.22	9.750
Asphalt and Road Oil	0.158	75.36	11.907
Crude Oil	0.138	74.49	10.280
Other fuels (solid)	**MMBtu / short ton**	**kg CO_2 / MMBtu**	**kg CO_2 / short ton**
Municipal Solid Waste	9.95[1]	90.7	902.465
Tires	26.87	85.97	2310.014
Plastics	38.00	75.00	2850.000
Petroleum Coke	30.00	102.41	3072.300
Other fuels (gaseous)	**MMBtu / scf**	**kg CO_2 / MMBtu**	**kg CO_2 / scf**
Blast Furnace Gas	0.092×10^{-3}	274.32	0.025
Coke Oven Gas	0.599×10^{-3}	46.85	0.028
Propane Gas	2.516×10^{-3}	61.46	0.155
Fuel Gas[2]	1.388×10^{-3}	59.00	0.082
Biomass Fuels (solid)	**MMBtu / short ton**	**kg CO_2 / MMBtu**	**kg CO_2 / short ton**
Wood and Wood Residuals	15.38	93.80	1442.644
Agricultural Byproducts	8.25	118.17	974.903
Peat	8.00	111.84	894.720
Solid Byproducts	25.83	105.51	2725.323
Biomass Fuels (gaseous)	**MMBtu / scf**	**kg CO_2 / MMBtu**	**kg CO_2 / scf**
Biogas (Captured methane)	0.841 x 10-3	52.07	0.044
Biomass Fuels (liquid)	**MMBtu / gallon**	**kg CO_2 / MMBtu**	**kg CO_2 / gallon**
Ethanol	0.084	68.44	5.749
Biodiesel	0.128	73.84	9.452
Rendered Animal Fat	0.125	71.06	8.883
Vegetable Oil	0.120	81.55	9.786

Appendix D. Alternative Soil Moisture Method

(a) Only precision leveling graded fields may use the method specified in this appendix.

(b) For fields employing this method, at the end of each drying the water level must be maintained at a level no lower than two inches below the leveled field surface at the top check.

(c) A ditch or a hole with a depth of at least six inches or at three times the largest dimension of the water level measuring gauge floatation device, whichever is larger, must be created.

 (1) The hole must be at least 15 inches wide in diameter.

 (2) The ditch or hole must represent the water level at the top check of a rice field and be outside a 50-foot radius of the water inlet.

(d) A water level measuring gauge, combining a supporting structure and a water level measuring device, must be constructed and installed in the ditch or hole.

(e) The supporting structure must

 (1) Be a steel pipe with a diameter of at least one half of an inch and a length of at least five feet, or a solid steel rod with a diameter of at least a quarter of an inch and a length of at least five feet, and

 (2) The supporting structure must be imbedded at least two feet in the soil and maintained in a position that is perpendicular to the water surface.

(f) The water level measuring device must:

 (1) Be secured to the supporting structure;

 (2) Be perpendicular to the water surface;

 (3) Have a floating device that can move up and down freely based on the level of water surface;

 (4) Have a ruler attached to the supporting structure. The ruler must be perpendicular to the water surface. The ruler must be positioned so the pointer of the floating device indicates the water level. The ruler must be numbered large and clear enough to obtain photographs when walking around the field perimeter.

(5) The ruler must be graduated in at least inch measurement at least four inches above and four inches below the soil surface;

(6) The floating device must have a pointer that moves up or down along with the floating device to indicate the water level on the ruler and accurately reflect the water level in the rice field;

(7) The ruler is calibrated to indicate zero when the water level is equal to the rice field's soil surface;

(8) The measuring device must be positioned to be able to measure every flooding scenario in the rice field;

(g) The water level measuring gauge must be calibrated before the first use of each rice cultivation year.

(h) The water level measuring gauge must be installed and maintained in a manner to assure readings within 0.25 inch of true value.

(i) The water level measuring gauge must be checked monthly for calibration accuracy.

(j) If the check reveals accuracy below the 0.25 inch threshold the field will be considered flooded until the water level measuring gauge is recalibrated and GHG reductions will not be accounted for or credited.