Wetland Implementation and Rice Cultivation in the Sacramento-San Joaquin Delta, San Francisco Estuary and the Coast of California – Methodology for Quantifying Greenhouse Gas Emissions Reductions, Version 1.0 – FRAMEWORK MODULE

Preface

The objective of this methodology is to describe quantification procedures for the reduction of greenhouse gas (GHG) emissions through conversion of land to wetlands and rice cultivation in the Sacramento-San Joaquin Delta, San Francisco Estuary and in coastal areas of California. The methodology has been written in a module format; Project Proponents can choose the applicable modules for their specific project and site. The Framework Module provides background and an over-arching description of the methodology requirements and modules. The remaining modules provide guidance for baseline and project scenario quantification, methods, modeling, calculation of uncertainty, and other quantification tools. Project Proponents should refer first to the Framework Module for applicability requirements and an outline of the specific modules necessary for their project type.

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(WR-MF) Wetland Implementation and Rice Cultivation Methodology – Framework

BACKGROUND

The objective of this methodology is to describe quantification procedures for reducing greenhouse gas (GHG) emissions through conversion of land to wetlands and rice cultivation in the Sacramento-San Joaquin Delta, San Francisco Estuary and in coastal areas of California. The methodology has been written in a module format; Project Proponents can choose the applicable modules for their specific project and site. The Framework Module provides background and an over-arching description of the methodology requirements and modules.

Baseline or business-as-usual scenarios include agriculture, seasonal wetlands and open water areas, where baseline emissions and carbon stock changes result primarily from oxidation of organic matter. Project scenarios include tidal wetlands restoration, and in the Sacramento-San Joaquin Delta permanently flooded managed non-tidal wetlands and rice cultivation. These activities stop or greatly reduce baseline emissions and in the case of wetlands, are net GHG sinks. Table 1 provides a list of relevant land uses and examples of each, which is not necessarily exhaustive.

Table 1. Relevant land use examples and GHG impact.

	Land Use	**Examples**	**Primary GHG Impact**
Baseline	Agricultural	Farmed organic soils on Delta islands	GHG emissions due to oxidation of organic soils
	Agricultural/fallow/seasonal wetlands	Fallow areas or areas that have become impractical to farm due to excessive wetness in the Sacramento-San Joaquin Delta.	GHG emissions due to oxidation of organic soils
	Seasonal Wetlands	Seasonally flooded hunting clubs in Suisun Marsh	GHG emissions due to oxidation of organic soils
	Open water	Subsided salt ponds in the South Bay, Franks Wetland in the Delta	Likely net GHG emissions (but no data exists)
Project	Managed non-tidal wetlands	Twitchell and Sherman islands	Generally net GHG removal (via increasing soil carbon sequestration), despite methane emissions
	Saline/brackish tidal wetlands	Rush Ranch, Suisun Marsh and others cited in Callaway and others[1]	Net GHG removal where there is minimal methane emitted
	Rice	Twitchell Island, Wright Elmwood Tract, Brack Tract, Rindge Tract, Canal Ranch Tract, Delta	Provides net GHG emission reductions on organic soils.

[1] Callaway, John C., Borgnis, Evyan L. Turner, R. Eugene & Milan, Charles S., 2012, Carbon Sequestration and Sediment Accretion in San Francisco Bay Tidal Wetlands, Estuaries and Coasts, (2012) 35:1163–1181.

In the following paragraphs, baseline and project activities are summarized according to currently eligible geographies.

Baseline Conditions

Sacramento-San Joaquin Delta

A key area for implementation of carbon sequestration wetlands and rice is within the 750,000-acre Sacramento-San Joaquin Delta. The Delta is a critical natural resource, an important agricultural region and the hub for California's water supply. Since Delta islands were first diked and drained for agriculture in the late 1800s, more than 3.3 billion cubic yards of organic soils have disappeared. This loss has resulted in land surface elevations as low as 20-25 feet below sea level (Figure 1). The volume below sea level (accommodation space) of approximately 1.7 million acre feet represents a significant opportunity for carbon sequestration.

The primary baseline emission and carbon stock change is due to oxidation of organic matter in farmed and grazed organic and highly-organic mineral soils. This oxidation results in emission of CO_2 and relatively small amounts of CH_4. Also, N_2O is emitted as the result of organic matter oxidation and fertilizer use. These emissions have occurred since the late 1800s due to drainage and cultivation of these soils. Baseline emissions of CO_2, CH_4 and N_2O have been measured and modeled. Specific information and a data summary are provided in Appendix C.

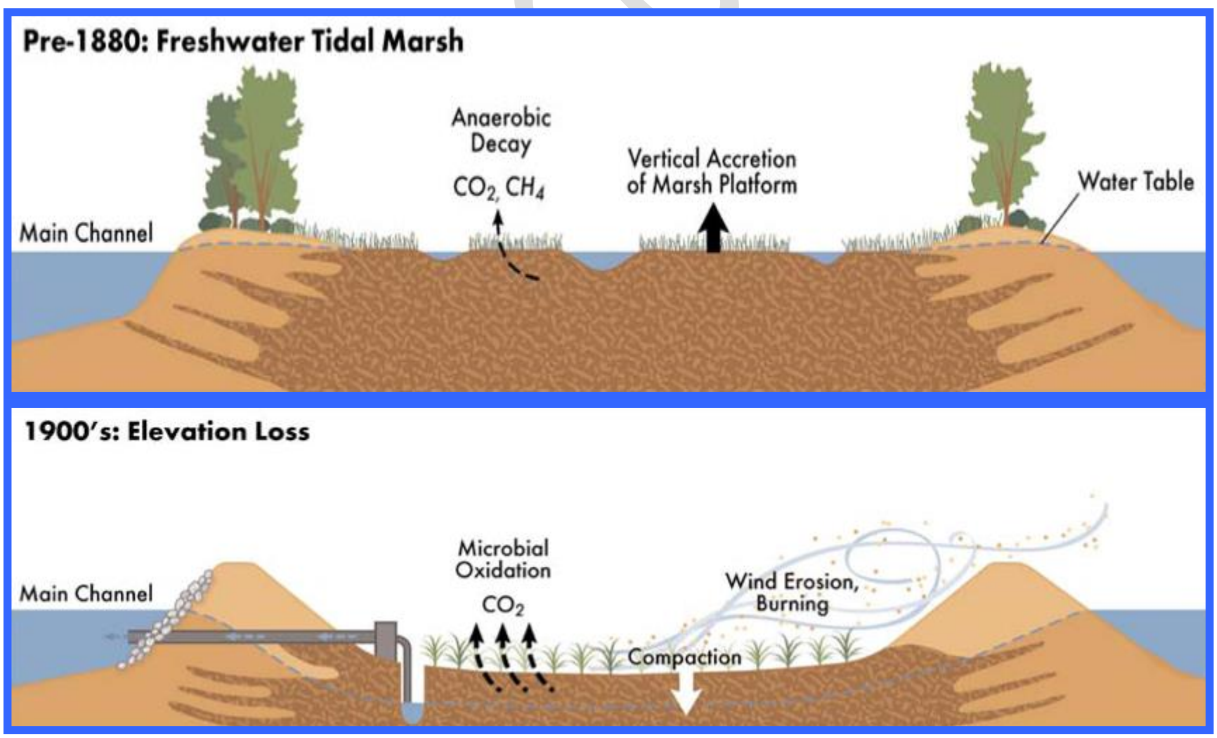

Figure 1. Evolution of Delta subsided islands (modified from Mount and Twiss[2]). During the last 6,800 years, organic soils accreted in a vast tidal marsh as sea level rose. Draining of the land for agriculture resulted in subsidence and loss of soil organic matter.

San Francisco Estuary

In the San Francisco Bay region, the primary baseline emission is due to oxidation of soil organic matter in seasonal wetlands with organic and highly-organic mineral soils. This oxidation results in emissions of CO_2, CH_4 and possibly N_2O. Consistent with the description of the oxidation of drained organic soils above, in an evaluation of different wetland management practices on highly organic mineral soils, USGS researchers determined that seasonal wetlands (flooded during late fall, winter and early spring) resulted in a net GHG emission[3]. Consistently, there are large areas of organic and highly organic mineral soils that have subsided. For example, the Suisun Marsh area is composed of both organic and mineral soils. Reported organic matter content for these soils ranges from 15 to 70 percent[4].

Most of the land within the Suisun Marsh consists of diked wetlands which are flooded part of the year. Approximately 85 percent of these wetlands are drained from mid-July through mid-September when soil temperatures and organic matter oxidation rates are high. In Suisun Marsh, estimated median subsidence rates from the late 1940s to 2006 varied by soil type and ranged up to 2.5 cm/year and were generally proportional to soil organic matter content.[5] The estimated volume below sea level based on the 2006 LIDAR data is 5,800 acre feet[6]. This is the approximate volume of organic soil that has been lost since initial diking and drainage. There have been few baseline measurements or estimates of GHG emissions in the Suisun Marsh or northern San Francisco Bay Area. Recently, the US Geological Survey deployed an eddy covariance tower at the Rush Ranch wetland in Suisun Marsh to measure GHG fluxes.

Open Water

An example area of applicability for this module is San Francisco Bay where diked and managed salt ponds preserved a large area of shoreline in an open state for salt crystallization. Former salt ponds are now open water areas that are undergoing phased conversion to tidal wetlands[7]. Over 15,000 acres

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[2] Mount J, Twiss R. 2005. Subsidence, sea level rise, seismicity in the Sacramento-San Joaquin Delta, San Francisco Estuary and Watershed Science. Vol. 3, Issue 1 (March 2005), Article 5.http://repositories.cdlib.org/jmie/sfews/vol3/iss1/art5

[3] Deverel, S.J., Wang, Bronwen, Rojstaczer, Stuart, 1998, Subsidence in the Sacramento-San Joaquin Delta, *in* (Borchers, J.W., ed.) Proceedings of the Joseph Poland Subsidence Symposium, Association of Engineering Geologists, Special Publication No. 8, Star Publishing, Belmont, California, pp. 489-502.
Robin L. Miller, Lauren Hastings, and Roger Fujii. 2000, Hydrologic Treatments Affect Gaseous Carbon Loss From Organic Soils, Twitchell Island, California, October 1995–December 1997, U.S. Geological Survey Water-Resources Investigations Report 00-4042.

[4] Bates, Leland A., 1977, Soil Survey of Solano County, California, U.S. Dept. of Agriculture, Soil Conservation Service.

[5] HydroFocus, Inc., 2007, Technical Memorandum, Recent And Estimated Future Subsidence Rates and Land Surface Elevation Changes in the Sacramento-San Joaquin Delta And Suisun Marsh, Delta Risk Management Strategy, Department of Water Resources, Sacramento, CA.

[6] HydroFocus, Inc., 2007, Technical Memorandum, Recent And Estimated Future Subsidence Rates and Land Surface Elevation Changes in the Sacramento-San Joaquin Delta And Suisun Marsh, Delta Risk Management Strategy, Department of Water Resources, Sacramento, CA. Assuming an organic soil bulk density of 0.2 g cm^{-3} and 50% organic matter, this volume of 5,800 acre feet translates to about 1.3 million tons of CO_2.

[7] http://www.southbayrestoration.org/.

have been reconnected to the bay or adjacent sloughs. Due to groundwater pumping in this area, many of the areas are substantially below sea level. These subsided lands are potentially influenced by processes that occur outside the project boundaries. For example, allochthonous carbon can enter the subsided areas. Also, there can be large primary productivity and respiration rates in these open water areas thus demonstrating the potential for baseline GHG emissions and removals[8].

Project Conditions

Managed Permanently-Flooded Non-Tidal Wetlands on Subsided Lands

The unique, chemically reducing environment in managed permanently-flooded wetlands on subsided lands facilitates CO_2 sequestration and Methanogenesis (production of CH_4). In permanently flooded wetlands, CO_2 accumulates in plant tissue which becomes litter and eventually accumulates as soil organic matter (SOM). The SOM can be converted to dissolved organic carbon (DOC), bicarbonate (HCO_3^-), and CH_4. Dissolved organic carbon and CH_4 are byproducts of and leakages from the net accumulation of SOM and CO_2 sequestration. Measurement of net wetland-surface accretion is accomplished through the use of documented techniques such as the use of sedimentation erosion table and collection and chemical analysis of cores of accumulating material.

Wetlands may be considered a GHG sink as CO_2 is removed from the atmosphere and stored in the soil carbon pool. However, a wetland also acts as a GHG source because it emits CH_4, which contributes to atmospheric radiative forcing. In general, the amount of CO_2 sequestered relative to the amount of CH_4 emitted and the relative ability of these gases to absorb infrared radiation ultimately determine whether the wetland is a sink or source for the global warming potential. Carbon fixation in the form of primary production is intimately connected with CH_4 production; the amount of CO_2 fixed on a daily basis has been positively correlated with CH_4 emissions[9]. The correlation of CH_4 emissions with Net Ecosystem Productivity is due to increases in organic substrates associated with root exudates, litter production, and plant turnover[10]. Since the late 1980s, there has been substantial interest in stopping and reversing the effects of subsidence by creating managed wetlands on subsided islands in the Sacramento-San Joaquin Delta. Additional information is provided in Appendix C.

Rice Cultivation on Subsided Lands in the Sacramento-San Joaquin Delta

Within the last 20 years, development of new rice varieties tolerant to low air and water temperatures resulted in Delta rice production with yields comparable to the Sacramento Valley. Available data indicates the combination of in-season and off-season flooding and addition of rice residues stop or greatly reduce oxidative soil loss. Rice has been successfully grown on over 3,000 acres on Delta islands

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[8] Thébault, Julien, Schraga, Tara S., Cloern, James E., Dunlavey, Eric G., 2008, Primary production and carrying capacity of former salt ponds after reconnection to San Francisco Bay, Wetlands, 28, 814-851.

[9] Whiting, G. J. and Chanton, J. P., 1993, Primary production control of methane emissions from wetlands. Nature 364, 794–795.

[10] Whiting, G.J. and Chanton, J.P., 2001, Greenhouse carbon balance of wetlands: methane emission versus carbon sequestration. Tellus, 53B, 521–528. Net Ecosystem Production is defined as the difference between gross primary production and respiration and represents the amount of carbon available for storage.

for over 10 years. Data reported for CO_2 and CH_4 emissions in rice by Hatala et al. and Knox et al.[11] and N_2O data reported by Ye and Horwath[12] demonstrate there is net GHG benefit for conversion to rice where soil organic carbon values range from 5 to 25 %.

Tidal Wetlands in San Francisco Estuary and California Coast

Reported GHG removal rates across or within tidal wetland complexes vary widely and are affected by local plant species composition and productivity, decomposition rates, allochthonous sediment imports, salinity, tidal range, and human activities. There are several large-scale restoration projects underway or planned in the San Francisco Bay Estuary (e.g., Montezuma Wetlands in Suisun Bay, Hamilton Wetlands, the Napa-Sonoma Salt Pond Project, and the South Bay Salt Pond Project) and elsewhere (e.g., Bolsa Chica Wetlands in Huntington Beach and San Deiguito Lagoon in San Diego). In the San Francisco Bay Estuary, tidal wetlands are mostly dominated by perennial pickleweed, *Sarcocornia pacifica*. Using two different dating systems (cesium-137 and lead-210), Calloway et al.[13] reported long-term carbon sequestration rates in the San Francisco Estuary ranging from 0.6 to 2.8 tons CO_2-e/acre-year. The average long-term rate for tidal salt and brackish wetlands was 1.6 tons CO_2-e/acre-year. Drexler[14] estimated millennial rates ranging from 0.6 to 1.1 tons CO_2-e/acre-year in remnant freshwater and brackish tidal marshes in the Delta.

Geographic Applicability

Due to the unique conditions described for the Sacramento-San Joaquin Delta and San Francisco Estuary, the methodology has been specifically developed for these geographic areas and may be used for tidal wetlands in California.

GENERAL GUIDANCE

A. Scope

The modules and tools described here are applicable for quantification of GHG removals and emission reductions for restoration of tidal wetlands (TW); managed, permanently flooded non-tidal wetlands (MW); and rice cultivation (RC) in the eligible geographies. The water quality of eligible activities ranges from fresh to saline and includes lands that are used for agriculture, managed or non-managed seasonal wetlands, and open water.

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[11] Hatala JA, Detto M, Sonnentag O, Deverel SJ, Verfaillie J, Baldocchi DD (2012) Greenhouse gas (CO_2, CH_4, H_2O) fluxes from drained and flooded agricultural peatlands in the Sacramento-San Joaquin Delta. Agriculture, Ecosystems and Environment 150: 1-18.
Knox SH, Sturtevant C, Matthes JH, Koteen L, Verfaillie J, Baldocchi D, 2014, Agricultural peatland restoration: effects of land-use change on greenhouse gas (CO_2 and CH_4) fluxes in the Sacramento-San Joaquin Delta, Global Change Biology, in press.
[12] Ye, R. and Horwath, W.R.,2014. Influence of variable soil C on CH_4 and N_2O emissions from rice fields 2013-2014. Presentation at UC Davis.
[13] Callaway, John C., Borgnis, Evyan L. Turner, R. Eugene & Milan, Charles S., 2012, Carbon Sequestration and Sediment Accretion in San Francisco Bay Tidal Wetlands, Estuaries and Coasts, (2012) 35:1163–1181.
[14] Drexler, J.Z., 2011, Peat Formation Processes Through the Millennia in Tidal Marshes of the Sacramento–San Joaquin Delta, California, USA, Estuaries and Coasts, DOI 10.1007/s12237-011-9393-7.

This methodology does not provide technical guidance for wetland construction, restoration, planting, rice cultivation or any project-related implementation. These activities require the expertise of designated experts such as (but not restricted to) certified wetland scientists, agronomists, hydrologists and civil and environmental engineers. The methodology assumes the Project Proponent has or engages the necessary expertise and requires that the activities implemented under this methodology comply with all applicable local, state, and national laws and regulations.

B. Sources of Information

The methodology structure and text have been adapted from the following methodologies:

- ACR Restoration of Degraded Deltaic Wetlands of the Mississippi Delta[15]
- VCS Methodology for Coastal Wetland Creation[16]
- ACR Emission Reductions Methodology in Rice Management Systems

[15] http://americancarbonregistry.org/carbon-accounting/standards-methodologies/restoration-of-degraded-deltaic-wetlands-of-the-mississippi-delta.
[16] http://www.v-c-s.org/methodologies/methodology-coastal-wetland-creation-v10.

C. Definitions and Acronyms

ACR	American Carbon Registry
A/R	Afforestation and or reforestation
ARR	Afforestation, reforestation, and revegetation
AFOLU	Agriculture forestry and other land use
Baseline	most likely management scenario in the absence of the project
C	Carbon
CDM	Clean development mechanism
CO_2	Carbon dioxide
CO_2-e	Carbon dioxide equivalent
CF	Carbon fraction
CH_4	Methane
ERT	Emission Reduction Ton
Ex-ante	'Before the event' or predicted response of project activity
Ex-post	'After the event' or measured response of project activity
GHG	Greenhouse gas
GIS	Geographic information system
GPS	Global positioning system
GWP	Global warming potential
Historical reference period	The historical period prior to the project Start Date that serves as the source of data for defining the baseline
i	Subscript used to represent a stratum
Leakage	Any change in carbon stocks or greenhouse gas emissions that occur outside a project's boundary (but within the same country) that is measurable and attributable to the project activity.
Module	Component of a methodology that can be applied on its own to perform a specific task
N_2O	Nitrous oxide
Open water	Coastal areas where there is no emergent vegetation.
QA	Quality assurance
QC	Quality control
Stratification	A standard statistical procedure to decrease overall variability of carbon stock estimates by grouping data taken from environments with similar characteristics (e.g., vegetation type; age class; hydrology; elevation)
Tool	Guideline or procedure for performing an analysis (e.g., Tool for testing significance of GHG emissions in A/R CDM project activities) or to help use or select a module or methodology
VCS	Verified Carbon Standard

D. Modules and Tools

The following modules and tools are available for use:

Baseline Modules:
BL-Ag - Estimation of agricultural baseline carbon stock changes and GHG emissions for wetland construction and rice cultivation where the project activity includes hydrologic management and infrastructural modification when there are agricultural activities in place immediately prior to the project commencement date

BL-SW - Estimation of baseline carbon stock changes and GHG emissions for managed and non-managed seasonal wetlands when the project case is wetland construction that includes hydrologic management and infrastructural modification

BL-OW – Estimation of open water baseline carbon stock changes and GHG emissions for tidal wetland restoration where the project activity includes hydrologic management and infrastructural modification.

Project Scenario Modules:
PS-MW Estimation of project scenario carbon stock changes and greenhouse gas emissions for construction of managed non-tidal permanently flooded wetlands where the project activity may include hydrologic management, infrastructural modification, and plantings or natural plant regeneration.

PS-TW Estimation of project scenario carbon stock changes and greenhouse gas emissions from tidal wetlands construction and restoration where the project activity may include levee breaching to create tidal influence, plantings, fill and salt flushing

PS-RC Estimation of project scenario carbon stock changes and greenhouse gas emissions from rice cultivation where the project activity may include hydrologic management, infrastructural modification, and rice cultivation

Methods Modules:
MM-W/RC Estimation of carbon stocks in the soil organic carbon pool and in the above- and below ground biomass and estimation of greenhouse gas emissions

E-FFC Estimation of emissions from fossil fuel combustion

MODEL-W/RC Biogeochemical models to be used for estimation of emissions and carbon stock changes under baseline and project conditions.

Uncertainty Modules:
X-UNC Estimation of uncertainty

Tools:

T-SIG	Tool for testing significance of GHG emissions in A/R CDM project activities
T-PERM	The currently approved ACR permanence risk tool
T-PLOTS	Calculation of the number of sample plots for measurements within A/R CDM project activities

Table 2. Determination of mandatory (M), conditional (C), or not required (N/R), module/tool use.

Determination	Module/Tool	Managed Wetland Construction	Tidal Wetland Restoration	Rice Cultivation
Used by all projects	WR-MF T-PERM X-UNC	M M M	M M M	M M M
Baselines	BL-Ag BL- SW BL- OW	C C C	C C C	M C N/R
Carbon Stocks	MM-W/R	M	M	M
Emissions	MM-W/RC E-FFC	M C	M C	M M
Project Scenario	PS-MW PS-TW PS-RC	M N/R N/R	N/R M N/R	N/R N/R M

Modules marked with an M are mandatory: the indicated modules and tools must be used. Modules marked with a C are conditional depending on the baseline scenario and emissions. Modules marked with N/R are not required. The optional pools and sources (Tables 3 and 4) can be included or excluded as determined by the project proponent; if included in the baseline they must also be included in the project scenario and be monitored accordingly.

E. Universal Applicability Conditions

Project Proponents must demonstrate to ACR and the Verifier that they have met the applicability conditions in the Framework Module, in any other modules utilized, and any overarching eligibility criteria set forth in the current version of the *ACR Standard*. The GHG Project Plan shall justify use of modules relevant to the proposed project activities.

Additional specific applicability conditions exist for each module and must be met for the module to be used. The following applicability criteria apply to all projects:

- All project activities must be in regulatory compliance.
- Must be located in the Sacramento-San Joaquin Delta, Suisan Marsh and/or tidal wetlands in California
- The project scenario, and associated baseline for each parcel of land included in the project must be one of the following combinations:
  - Managed permanently shallow flooded wetlands on subsided lands where the baseline includes agricultural areas which result in continued organic soil loss in the Sacramento-San Joaquin Delta;
  - Managed permanently shallow flooded wetlands on subsided lands where the baseline includes seasonal wetlands in the Sacramento-San Joaquin Delta or Suisun Marsh;

    - Tidal wetland restoration in the San Francisco Estuary where the baseline is open water areas in former salt ponds;
    - Tidal wetland restoration in the San Francisco Estuary where the baseline is seasonal wetlands on organic soils which result in continued organic soil loss - these areas include managed seasonally flooded wetlands and areas that have become too wet to farm and have become seasonal wetlands and hunting clubs in the Sacramento-San Joaquin Delta and San Francisco Estuary;
    - Rice cultivation on subsided lands in the Sacramento-San Joaquin Delta where the baseline is farmed organic soils using crops that required a drained root zone
- Eligible management strategies to achieve these project activities include:
    - Alteration of hydrologic conditions, sediment supply, water quality, plant communities, and nutrient management
    - Earth moving
    - Diversion of channel water into wetlands or rice fields
    - Management of surface water levels and wetland outflow
    - Levee breaching with appropriate permits

The project is not eligible if it employs any of the following:

- Drainage of wetland soils;
- Activities that cause deleterious impacts or diminish the GHG sequestration function of habitat outside the project area;
- Activities that will result in a reduction of wetland restoration activities or increase wetland loss outside of the project boundary;
- Burning of wetland or agricultural vegetation;
- Activities required under any law or regulation, including Section 404 of the Clean Water Act to mitigate onsite or offsite impacts to wetlands;
- Activities that involve the use of natural resources within the project boundary that lead to further environmental degradation (fishing, hunting, etc. that do not lead to degradation of the project area are permitted);
- Harvesting of wood products;
- Planting of non-native species;
- Activities that affect fish populations in Delta channels[17].

The Project Proponents shall provide attestations and/or evidence (e.g. permits or permit applications) of environmental compliance to the American Carbon Registry (ACR) at the time of GHG Project Plan submission, and to the validation/verification body at the time of validation, and at each verification. Any changes to the project's regulatory compliance status shall be reported to ACR immediately.

F. Applicable Project and Baseline Modules

Figure 2 shows the relationships between project and Baseline Modules. For the managed wetlands project activity, agricultural and/or seasonal wetlands Baseline Modules can be employed depending on baseline conditions. For the rice cultivation project activity, only the agricultural baseline is applicable. For tidal wetlands project activity, either the seasonal wetland or open water Baseline Modules are

[17] Siphoning of water for wetlands on subsided Delta islands may result in "take" of fish. Fish screens or an alternative mitigation measure may be required to avoid take.

applicable.

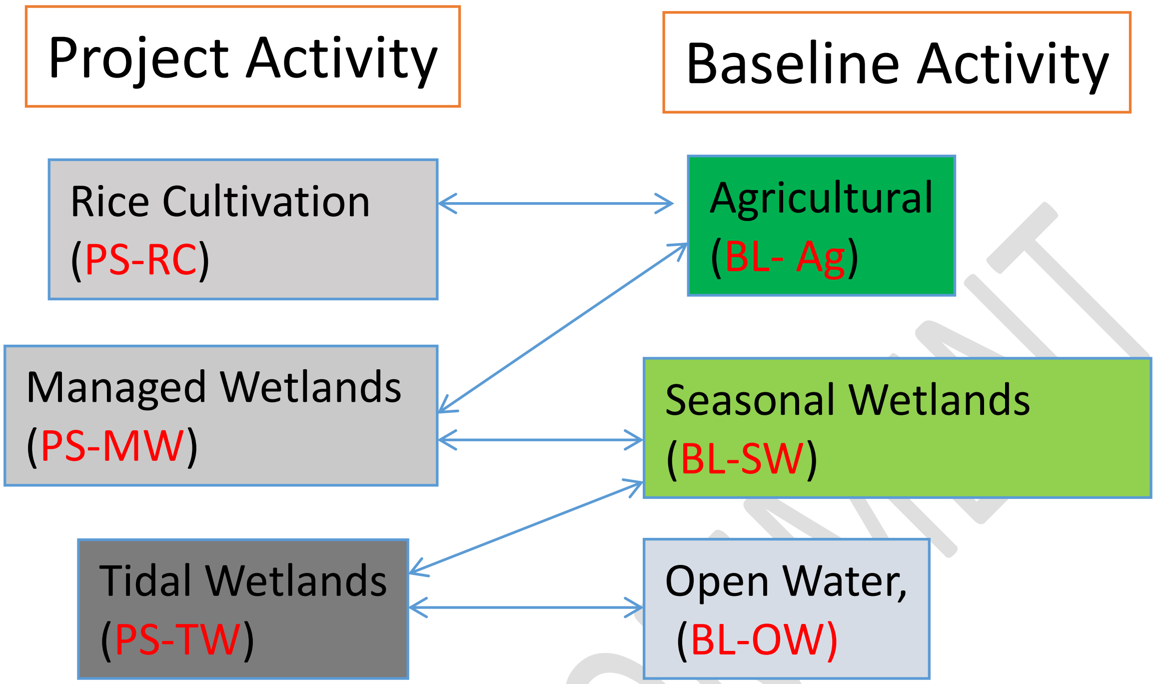

Figure 2. Project and Baseline Modules.

ASSESSMENT OF NET GREENHOUSE GAS BENEFIT

The project proponent shall implement the following steps to assess greenhouse gas reductions.

1. Identification of the baseline activities
2. Definition of project boundaries
3. Demonstration of additionality
4. Development of a monitoring plan
5. Estimation of baseline carbon stock changes and GHG emissions
6. Estimation of project carbon stock changes and GHG emissions
7. Estimation of total net GHG emission reductions (project minus baseline and leakage)
8. Calculation of uncertainty
9. Risk assessment
10. Calculation of Emission Reduction Tons (ERTs)

All steps are required *ex-ante*. For *ex-post*, steps 6 through 10 are applicable. For parameters that will be monitored or modeled subsequent to project initiation, *ex-ante* guidance is given in the relevant modules, MODEL–R/C, MM-R/C, and E-FFC.

Step 1. Identification of the Baseline Activities

Use the flow chart (Figure 2) to identify the appropriate project activity, baseline and relevant modules. A project can include areas with different baselines. In such cases, project and baseline areas shall be delineated in the GHG Project Plan.

Proponents must demonstrate that one of the permissible Baseline Scenarios is credible for their project area by describing what would have occurred in absence of the Project Activities and quantifying GHG emissions and removals. The Baseline Scenarios must be limited to the specified baseline land uses shown in Figure 2 and comply with the applicability conditions described in the framework, Project and Baseline modules.

Step 2. Definition of Project Boundaries

The following categories of boundaries shall be defined:

- The geographic boundaries relevant to the project activity;
- The temporal boundaries;
- The carbon pools that the project will consider and;
- The sources and associated types of GHG emissions

a. Geographic boundaries relevant to the project activity

The Project Proponents must provide a detailed description of the geographic boundary of project activities using a Geographic Information System (GIS). Information to delineate the project boundary may include:

- USGS topographic map or property parcel map where the project boundary is recorded for all areas of land. Provide the name of the project area (e.g., compartment number, allotment number, local name); and a unique ID for each discrete parcel of land
- Aerial map (e.g. orthorectified aerial photography or georeferenced remote sensing images)
- Geographic coordinates for the project boundary, total land area, and land holder and user rights

Project proponents shall provide a GIS shapefile that includes relevant geographic features and the project boundaries

Where multiple baselines exist there shall be no overlap in boundaries between areas appropriate to each of the baselines. Project activities may occur on more than one discrete area of land, but each area must meet the project eligibility requirements. This methodology allows for “Programmatic Aggregated Projects”; new wetland areas may be added to an existing Project after the start of the crediting period as long as all the applicability criteria are met for each new area. The current *ACR Standard* provides guidelines and requirements for projects using a programmatic aggregation design.

b. Temporal Boundaries

The project Start Date is defined as the day Project Proponents began verifiable activities to increase carbon stocks and/or reduce GHG emissions. This methodology employs a 40-year Crediting Period, over which time monitoring and verification must take place at specified intervals to ensure that there are no reversals of carbon stocks. Spatial and temporal patterns of tidal and freshwater wetlands are dynamic, resulting from complex and interactive effects of natural and human-induced processes. These factors shall be accounted for in project monitoring and reporting.

c. Carbon Pools and Sources

Tables 3 and 4 provide guidelines for determining the GHG assessment boundary. Exclusion of carbon pools and emission sources is allowed subject to considerations of conservativeness and significance testing or when inclusion may result in double counting. This can be the case for plant litter, above and below ground biomass and soil organic matter pools. Pools or sources may always be excluded if conservative, i.e. exclusion will tend to underestimate net GHG emission reductions or removal enhancements. Pools, sinks or sources can be excluded (i.e., counted as zero) if application of the tool T-SIG indicates that each source, sink and pool is determined to be insignificant and can be excluded from accounting, i.e. it represents less than 3% of the *ex-ante* calculation of GHG emission reductions/removal enhancements (per ACR *Forest Carbon Project Standard*).

Table 3. Carbon pools to be considered for monitoring or modeling.

Carbon pool	Status	Explanation/Justification	Quantification Methods
Above-ground non-woody biomass	Optional	Major carbon pool affected by Project activity. May be conservatively omitted from field measurements and monitoring to prevent double counting. Included when biogeochemical modeling is used to estimate GHG dynamics in the project and baseline scenario	Biogeochemical models calibrated and validated for project or baseline conditions, Digital photography and leaf area index (LAI), remote sensing, allometric and destructive methods and digital photography, peer-reviewed literature values.
Below ground biomass (associated with non-woody above-ground biomass)	Required when utilizing biogeochemical modeling/ excluded otherwise	Major Project carbon pool affected by project activity. May be conservatively omitted from field monitoring. Included when biogeochemical modeling is used to estimated GHG dynamics in the project and baseline scenarios	Biogeochemical model calibrated and validated for project or baseline conditions, field measurement, and literature values.
Litter	Optional	Result of decaying wetland vegetation and contributes to soil organic carbon. May be conservatively omitted from field monitoring. Included when biogeochemical modeling is used to estimate GHG dynamics in the project and baseline scenario	Biogeochemical model calibrated and validated for project or baseline Conditions, litter bags, literature values.
Crop residue	Optional	Plant biomass (including rice) incorporated into the soil organic matter pool. May be conservatively omitted from field monitoring. Included when biogeochemical modeling is used to estimate GHG dynamics in the project and baseline scenario	Biogeochemical model calibrated and validated for project or baseline conditions, field measurements.
Soil organic matter	Included	Major baseline and project carbon pool. Soil organic carbon stock will likely increase due to the implementation of project activity Included when biogeochemical modeling is used to estimate GHG dynamics in the project and baseline scenario	Monitored using methods described in Methods Module (MM-W/RC). A biogeochemical model calibrated and validated for Project or Baseline conditions can be used (MODEL-W/R)
Harvested biomass	Included for Baseline	Key component of carbon balance for agricultural baseline and rice	Modeling or measurement of harvested product and estimation of carbon content as described in the Methods Module (MM-W/R)

Table 4. Greenhouse gas sources.

	Source	Gas	Status	Justification/Explanation	Quantification Method
Baseline	The production of methane by bacteria	CH_4	Optional	May be conservatively excluded	Field measurement as described in the Methods Module (MM-W/R) module and/or biogeochemical model calibrated and validated for Baseline Conditions (MODEL-W/R).
	Nitrogen transformations due to fertilizer application or organic soil oxidation	N_2O	Optional	May be conservatively excluded	Field measurement as described in the Methods Module (MM-W/R) module and/or biogeochemical model calibrated and validated for Baseline Conditions (MODEL-W/R).
	Oxidation of organic soils	CO_2	Included	Primary baseline emission	Field measurement as described in the Methods Module (MM-W/R) and/or biogeochemical model calibrated and validated for Baseline Conditions (MODEL-W/R).
	Emissions from Fossil Fuel Combustion	CO_2	Included	Primary fossil fuel emission	Calculations described in emissions module (E-FFC)
		N_2O	Excluded	Minor emissions source	
		CH_4	Excluded	Minor emissions source	
Project	The production of methane by bacteria	CH_4	Included/Optional	Primary project emission for all project scenarios. May be excluded in saline tidal marshes under conditions specified in the tidal wetland module (PS-TW).	Field measurement as described in the Methods Module (MM-W/R) module and/or biogeochemical model calibrated and validated for Project Conditions (MODEL-W/R).
	Nitrogen transformations due to fertilizer application or organic soil oxidation	N_2O	Included/Optional	Must be included for rice cultivation. Optional for all other project activities[18].	Field measurement as described in the Methods Module (MM-W/R) module and/or biogeochemical model calibrated and validated for Project Conditions ((MODEL-W/R).
	Oxidation of organic soils	CO_2	Included/Optional	Must be included for rice cultivation. Optional for all other project activities.	Field measurement as described in the Methods Module (MM-W/R) module and/or biogeochemical model calibrated and validated for Project Conditions ((MODEL-W/R).).
	Emissions from fossil fuel combustion	CO_2	Included	May be excluded if justified by demonstrating that fossil fuel emissions for project conditions or equal to or less than baseline conditions.	Calculations described in emissions module (E‐FFC).
		N_2O	Excluded	Minor emissions source	
		CH_4	Excluded	Minor emissions source	

d. Leakage for Agricultural Baseline

[18] N_2O emissions can be ignored in permanently flooded wetland conditions. Under permanently flooded soil conditions, N_2O is consumed during denitrification and converted to N_2. See for example:
Butterbach-Bahl K, Baggs EM, Dannenmann M, Kiese R, Zechmeister-Boltenstern S (2013) Nitrous oxide emissions from soils: how well do we understand the processes and their controls? *Philosophical Transactions of the Royal Society B: Biological Sciences,* **368**, 20130122.

Leakage is an increase in GHG emissions outside the project boundaries that occurs as a result of the project action. ACR requires Project Proponents to assess, account for, and mitigate for leakage above de-minimis levels. Project Proponents must deduct leakage that reduces the GWP benefit of a project in excess the applicable threshold specified in the methodology (3%). Activity-shifting leakage occurs when the land uses resulting in baseline emissions that operated in the project area before the project start date are relocated to another area outside of the project boundary. Market-effects leakage is transmitted through market forces; a supply reduction can result in an upward pressure on price that may incentivize increased production and shifts in cropping patterns elsewhere. The change in the GWP as the result of these market-effects leakage shall be accounted for in the net project GHG removals. For the activities included in this methodology, only market-effects leakage would result from replacement of crops currently grown in the Delta by wetlands and rice. All other project scenarios need no further leakage analysis and may use a leakage value of zero.

As part of this methodology development, a leakage analysis was conducted for replacement of traditional crops in the Delta with wetlands and rice. First an economic analysis was conducted to determine how crop acreages statewide would be affected by Delta land conversion. Next, the estimated the change in GWP was estimated as the result of this crop-area change. The report describing the results is included as a supplementary document.

A peer-reviewed, statewide agricultural economic model that simulates market-driven changes for over 6 million acres of California agriculture, was used to estimate crop acreage changes for the following alternatives in which land-use changes were simulated to occur by 2030; conversion of traditional field crops and pasture to wetlands or rice. Where a policy removed land from production and allocated it to wetlands, this acreage was not modeled specifically as a crop in the model but modeled as fallow land. Field crops and pasture predominate in areas where there are oxidizing organic soils that contribute to baseline carbon dioxide emissions.

1. No Action Alternative (NAA)
2. Remove 35,000 acres of field crops from the Delta and leave the land fallow
3. Remove 35,000 acres of field crops from the Delta and convert those acres to rice
4. Remove 10,000 acres of irrigated pasture from the Delta and leave the land fallow
5. Remove 10,000 acres of irrigated pasture from the Delta and convert those acres to rice

To estimate GWP changes, the results of statewide GHG modeling and field experiments for over 40 crops were used. The GWP changes were aggregated into the 7 groups used in the economic model analysis and the GWP was estimated on a per acre basis. We used the estimated GWP in tons of CO_2 equivalents per acre per year multiplied by the non-Delta acreage changes for the crop groups to estimate the potential GWP leakage for each scenario. In all alternatives except for alternative 4, the range of GWP changes by incorporating uncertainty was 3% or less relative to baseline emissions. For alternative 4, the range of GWP was 4% or less relative to baseline emissions. Therefore, for managed wetlands and rice projects implemented on agricultural lands that include less than 35,000 acres of crop land or 10,000 acres of pasture, no leakage deduction is required. Additional leakage analysis is required if the cumulative acreage of wetlands and rice acreage in the Sacramento-San Joaquin Delta exceeds these acreages.

e. Stratification

Stratification is a standard procedure to decrease overall variability of carbon stock estimates by grouping data taken from environments with similar characteristics. When estimating baseline emissions, several strata can be assessed. If the area is not homogeneous, stratification shall be implemented to improve the accuracy and precision of carbon stock estimates. Different stratifications may be required for the baseline and project scenarios, especially if there will be a change in hydrology, in order to achieve optimal accuracy and precision of the estimates of net GHG benefit. Within each module, specific guidelines are provided for stratification.

The stratification for *ex-ante* estimations shall be based on the content of the project monitoring plan. The stratification for *ex-post* estimations shall be based on the actual implementation of the project monitoring plan. If natural or anthropogenic impacts (e.g., levee breaks and flooding) or other factors (e.g., altered hydrology or water management) add variability in the vegetation of the project area, then the stratification shall be revised accordingly. Project Proponents may use remotely sensed data acquired close to the time of project commencement and/or the occurrence of natural or anthropogenic impacts for *ex-ante* and *ex-post* stratification.

Step 3. Demonstration of Additionality

Eligible offsets must be generated by projects that yield surplus GHG reductions that exceed any GHG reductions otherwise required by law or regulation or any GHG reduction that would otherwise occur in a conservative business-as-usual scenario. These requirements are assessed through the Legal Requirement Test and the Performance Standard Evaluation.

a. Legal Requirement Test

Emission reductions achieved by a Rice Cultivation or Wetland project must exceed those required by any law, regulation, or legally binding mandate as required in the jurisdiction where they are located. The following legal requirements apply to all Rice Cultivation and Wetland projects:

I. The activities that result in GHG reductions and GHG removal enhancements are not required by law, regulation, or any legally binding mandate applicable in the offset project's jurisdiction, and would not otherwise occur in a conservative common practice business-as-usual scenario.

II. 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 GHG 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.

b. Performance Standard Evaluation

Emission reductions achieved by a Rice Cultivation or Wetland project must exceed those likely to occur in a conservative business-as-usual scenario and are subject to the following practice-based performance standard for wetlands and rice cultivation.

c. Practice-based Performance Standards

I. Managed Non-Tidal Permanently Flooded Wetlands on Subsiding Lands Where Organic and Highly Organic Mineral Soils are Present in the Sacramento-San Joaquin Delta

Managed, permanently flooded, non-tidal wetlands on lands which were formally in agriculture currently represent less than 2 percent of the approximately 200,000 acres where organic and highly organic mineral soils are present and subsiding to various degrees in the Sacramento-San Joaquin Delta[19]. Costs for conversion of agricultural land to managed non-tidal wetlands range from $600[20] to over $6,000[21] per acre. Because wetland restoration is not a common practice among Delta landowners, Managed Non-Tidal Wetland projects using this methodology are deemed "beyond business as usual" and therefore additional. Thus, a Managed Non-Tidal Wetland Project that occurs on agricultural land where there are organic or highly organic mineral soils satisfies the Practice-Based Performance Standard. There will likely be an increase in wetland acreage over time, which will change the results of the analyses used to establish and validate the performance standard. ACR reserves the right to review and require revisions to this performance standard as necessary at an interval no less frequent than once every 10 years following the approval of this Methodology.

II. Rice Cultivation on Subsiding Organic Soils and Highly Organic Mineral Soils in the Sacramento-San Joaquin Delta

Rice currently represents less than 3 percent of the approximately 200,000 acres where organic and highly organic mineral soils are present and subsiding to various degrees in the Sacramento-San Joaquin Delta. Costs for conversion of agricultural land farmed to traditional crops such as corn to rice range from $116[22] to over $1,000[23] per acre. Because Conversion to Rice Cultivation is not common practice by Delta landowners, projects using this methodology are deemed "beyond business as usual" and therefore additional. Therefore, a Rice Cultivation Project that occurs on agricultural land where there are organic or highly organic mineral soils satisfies the Practice-Based Performance Standard. There will likely be additional rice acreage during next decade. ACR reserves the right to review and require revisions to this performance standard as necessary at an interval no less frequent than once every 10 years following the approval of this Methodology.

III. Tidal wetlands in San Francisco Estuary

San Francisco Bay has lost an estimated 90 percent of its historic wetlands to fill or alteration[24]. Tidal wetlands currently represent about 16% of the approximately 208,000 acre area of historic wetlands in

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[19]Steven J. Deverel, Christina E. Lucero, Sandra Bachand, 2014, Evolution of reduced arability on organic and highly organic mineral soils, Sacramento-San Joaquin Delta, California, in review, San Francisco Estuary and Watershed Science.

[20]A. Merrill, S. Siegel, B. Morris, A. Ferguson, G. Young, C. Ingram, P. Bachand, Holly Shepley, Maia Singer, Noah Hume. 2010. Greenhouse Gas Reduction and Environmental Benefits in the Sacramento-San Joaquin Delta: Advancing Carbon Capture Wetland Farms and Exploring Potential for Low Carbon Agriculture. Prepared for The Nature Conservancy, Sacramento, California. Available at: (http://www.stillwatersci.com/).

[21]Brock, Bryan, Engineer, California Department of Water Resources, Personal Communication, June, 2011.

[22] Canivari, M., Klonski, K. M. And DeMoura, R.L., 2007, Sample costs to produce rice in 2007 for the Delta Region for continuous rice culture.

[23] Brock, Bryan, Engineer, California Department of Water Resources, Personal Communication, June, 2011.

[24] Rubissow Okamoto, Ariel and Wong, Kathleen M., 2011, *Natural History of the San Francisco Bay*, University of California Press, Berkeley, CA.

the San Francisco Estuary.[25] Because tidal wetlands restoration is not common practice, projects using this methodology are deemed "beyond business as usual" and therefore additional. Therefore, a Tidal Wetlands Project that occurs in the San Francisco Estuary in areas of former historic wetlands satisfies the Practice-Based Performance Standard. ACR reserves the right to review and require revisions to this performance standard as necessary at an interval no less frequent than once every 10 years following the approval of this Methodology.

Step 4. Development of a Monitoring Plan

Project Proponents shall include a single monitoring plan in the GHG Project Plan. For monitoring changes in wetland cover and carbon stock changes, the monitoring plan shall use the methods given in the model and Methods Modules (MM-W/R, MODEL-W/RC) and relevant Project Modules (PS-MW, PS-RC, or PS-TW). All relevant parameters from the modules shall be included in the monitoring plan. Monitoring shall occur for the life of the project.

The monitoring plan shall include the following:

1. Definition and revision of the baseline[26] (as needed);
2. Monitoring of actual carbon stock changes and GHG emissions;
3. Estimation of *ex-post* net carbon stock changes and greenhouse gas emissions.

For each of these tasks, the monitoring plan shall include the following sections:

a. Technical description of the monitoring task
b. Data to be collected. The list of data and parameters to be collected shall be given in the GHG Project Plan
c. Description of data collection and/or sampling procedures
d. Use of biogeochemical models for estimating emissions and carbon stock changes if used
e. Quality control and quality assurance procedures
f. Data archiving plan
g. Organization and responsibilities of the parties involved in all the above

Step 5. Estimation of Baseline Carbon Stock Changes and Greenhouse Gas Emissions

Per the most recent version of ACR Standards, the GHG project baseline is a forecast of the likely stream of emissions or removals to occur if the Project Proponent does not implement the project, i.e., the "business as usual" case. There are various potential approaches to baseline determination, including existing actual or historical emissions or emissions of activities undertaken in a recent period in similar social, economic, environmental and technological circumstances. For example, the agricultural baseline emissions could be measured at the project site using methods described in the Methods Module (MM-W/R) or estimated using eligible biogeochemical models. Alternatively, emissions could be measured for a reference site with sufficiently similar agricultural practices, hydrologic conditions and soils. Forecasted emissions can be determined using biogeochemical models calibrated for the Delta.[27]

[25] Bayland Goals Technical Update, Chapter 7 – Carbon Accounting and GHG Flux.
[26] Baselines are only revised at the end of the crediting period.
[27] Deverel S.J. and Leighton D.A., 2010, Historic, Recent, and Future Subsidence, Sacramento-San Joaquin Delta, California, USA. San Francisco Estuary and Watershed Science 8(2). http://www.escholarship.org/uc/item/7xd4x0xw.

The following modules contain methods for estimating baseline carbon stock changes and greenhouse gas emissions (see Figure 2):

- Agriculture (BL-Ag)
- Seasonal wetlands (BL-SW)
- Open water or seasonally inundated (BL-OW)

A description of and justification for the identified baseline scenario and the results of the estimations shall be given in the GHG Project Plan.

Step 6. Estimation of Project Carbon Stock Changes and Greenhouse Gas Emissions

The following modules contain guidance for estimating project carbon stock changes and greenhouse gas emissions for projects where wetlands and rice cultivation are planned (Figure 2):

- Managed wetlands (PS-MW)
- Tidal wetlands (PS-TW)
- Rice cultivation (PS- RC)

Methods for estimation of project carbon stock changes and greenhouse gas emissions are described in the Methods Module (MM-W/R).

Step 7. Estimation of Total Net Greenhouse Gas Emissions Reductions (project minus baseline and leakage)

The total net greenhouse gas project reductions are calculated as follows:

$$\Delta C_{ACR,t} = (\Delta C_{actual} - \Delta C_{BSL}) * (1\text{-}LK) \qquad (1)$$

where:

$\Delta C_{ACR,t}$ is the cumulative total net greenhouse gas emission reductions at time *t* (t CO_2-e);

ΔC_{actual} is the cumulative total of carbon stock changes and greenhouse gas emissions under the project scenario since the last reporting period (t CO_2-e) (from the selected Project Module);

ΔC_{BSL} is the cumulative total of carbon stock changes and greenhouse gas emissions under the baseline scenario up to time t (t CO_2-e) (from the selected individual baseline, or the sum of selected baselines if the project includes more than one baseline); and

LK is the cumulative total of the carbon stock changes and greenhouse gas emissions due to leakage up to time t expressed as a fraction of ΔC_{BSL}

a. Use of Models

Models can be useful tools for estimating GHG dynamics in the baseline and project scenarios. Process-based biogeochemical models may be used to estimate changes in various carbon pools and GHG sources in this methodology. Project proponents must validate and calibrate models for the soils, hydrologic and biogeochemical conditions in the proposed project area. Models must:

- Be documented in the peer-reviewed literature;
- Be validated in the Project Area or similar sites using peer-reviewed or other quality controlled data (i.e. collected as part of a Government soils inventory or experiment) for baseline and project conditions;
- Be parameterized using peer-reviewed or other quality-controlled data appropriate to each identified strata;
- Be able to effectively simulate GHG emissions and removals and carbon stock changes for baseline and project conditions;
- Models that include litter, above and below ground biomass and soil organic matter pools must demonstrate that there is no double counting of carbon pools and include consideration of conservativeness and significance testing;
- Use of models shall be conservative in estimating GHG emission reductions.

Step 8. Calculation of Uncertainty

Project proponents shall use X-UNC to calculate overall project uncertainty and estimate the uncertainty adjustment for total net GHG emissions reductions for every reporting period. If calculated total project uncertainty (UNC) exceeds 10% at the 90% confidence level, then $C_{ACR,t}$ (Equation 1) shall be adjusted as follows:

$$Adjusted\ \Delta C_{ACR,t} = \Delta C_{ACR,t} * (100\% - UNC + 10\ \%) \qquad (2)$$

where:

Adjusted $\Delta C_{ACR,t}$ is the cumulative total net GHG emission reductions at time *t* adjusted to account for uncertainty (t CO_2-e);

$\Delta C_{ACR,t}$ is the cumulative total net greenhouse gas emission reductions at time *t* (t CO_2-e); and

UNC is the total uncertainty (project and baseline) as derived in X-UNC (%).

If the calculated total project uncertainty (UNC) in module X-UNC is less than or equal to 10%, then no adjustment shall be made for uncertainty.

Step 9. Risk Assessment

Project activities have the potential for GHG reductions and removals to be unintentionally reversed, such as when a project is subject to flooding, damage from wildlife, erosion; or intentional reversals or termination, such as landowners choosing to discontinue project activities before the project minimum term has ended. Wetland offsets are inherently at some risk of reversal or termination. Project Proponents shall mitigate reversal and termination risk per the requirements of the current ACR

Standard and any applicable sector Standard.

To assess the risk of reversal or termination, the Project Proponents shall conduct a risk assessment addressing internal, external and natural risks using the most recently approved ACR risk assessment tool. Internal risk factors include project management, financial viability, opportunity costs and project longevity. External risk factors include factors related to land tenure, community engagement and political forces. The primary natural termination risk to wetlands and rice projects in the in the San Joaquin Delta and San Francisco Estuary is flooding due to sea level rise and/or levee failure. Levee failure and flooding in managed non-tidal wetlands and rice on subsided islands in the Sacramento-San Joaquin Delta will result in termination and reversal of cumulated GHG removals if the island is not reclaimed. The Delta Risk Management Strategy Project calculated the risk of levee failure throughout Delta and Suisun Marsh[28] for baseline conditions. However, risk of levee failure will be reduced by implementation of constructed non-tidal wetlands on subsided Delta islands.[29]

The output of ACR's most-recently approved version of the risk assessment tool is a total risk rating for the project which equals the percentage of offsets that must be deposited in the ACR buffer pool to mitigate the risk of reversal or termination (unless another ACR approved risk mitigation mechanism is used in lieu of buffer contribution). The risk assessment, overall risk rating, and proposed mitigation or buffer contribution shall be included in the GHG Project Plan.

a. Mitigation of Risk via the ACR Buffer Pool

For Project Proponents choosing the ACR buffer pool, the Project Proponents shall contribute either a portion of the project offsets, or an equal number of ERTs of another type and vintage, to a buffer account held by ACR in order to replace unforeseen losses of carbon stocks. The number of ERTs contributed to the buffer pool shall be determined through the Risk Assessment. Buffer contributions are made with each new issuance of ERTs to a project.

In lieu of making a buffer contribution of ERTs from either the project or purchased from another acceptable source, Project Proponents may use an alternate ACR-approved risk mitigation mechanism, or propose an insurance product or other risk mitigation mechanism to ACR for approval.

Step 10. Calculation of Emission Reduction Tons (ERTs)

$$ERTt = (\Delta C_{ACR,t}) * (1 - BUF) \qquad (3)$$

where:

ERTt is the number of Emission Reduction Tons during the reporting period (t CO_2-e);

$\Delta C_{ACR,t}$ is the cumulative total net greenhouse gas emission reductions at time *t* (t CO2-e); and

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[28] http://www.water.ca.gov/floodsafe/fessro/levees/drms/docs/drms_execsum_ph1_final_low.pdf.

[29] Deverel, Steven J.; Ingrum, Timothy; Lucero, Christina; & Drexler, Judith Z. (2014). Impounded Marshes on Subsided Islands: Simulated Vertical Accretion, Processes, and Effects, Sacramento-San Joaquin Delta, CA USA. San Francisco Estuary and Watershed Science, 12(2). jmie_sfews_12893. http://escholarship.org/uc/item/0qm0w92c.

BUF is the fraction of project ERTs contributed to a buffer pool, if applicable.

Per the *Forest Carbon Project Standard, BUF* is determined using an ACR-approved risk assessment tool. If the Project Proponent elects to make the buffer contribution in non-project ERTs, or elects to mitigate the assessed reversal risk using an alternate risk mitigation mechanism approved by ACR, *BUF* shall be set to zero.

PARAMETERS ORIGINATING IN OTHER MODULES

Data /parameter:	ΔC_{BSL}
Data unit:	t CO_2-e
Used in Equations:	1
Description:	Cumulative total of carbon stock changes and greenhouse gas emissions for the baseline scenarios where there are agricultural activities in place immediately prior to the project commencement date.
Module parameter originates in:	BL-AG, BL-SW, or BL-OW

Data /parameter:	ΔC_{actual}
Data unit:	t CO_2-e
Used in Equations:	1
Description:	Cumulative total of carbon stock changes and greenhouse gas emissions for the project scenario where the project activity can include hydrologic management, infrastructure modification, and plantings or natural plant recruitment.
Module parameter originates in:	PS-MW, PS-TW, or PS-RC

Data /parameter:	LK
Data unit:	Fraction (dimensionless)
Used in Equations:	1
Description:	Cumulative total of the carbon stock changes and greenhouse gas emissions due to leakage up to time t expressed as a fraction of ΔC_{BSL}
Module parameter originates in:	Leakage analysis

Data /parameter:	BUF
Data unit:	t CO_2-e
Used in Equations:	1
Description:	Cumulative total of carbon stock changes and greenhouse gas emissions for the project scenario where the project activity can include hydrologic management, infrastructure modification, and plantings or natural plant recruitment.
Module parameter originates in:	PS-MW, PS-TW, or PS-RC

Data /parameter:	UNC
Data unit:	Percentage
Used in Equations:	2
Description:	Total uncertainty (project and baseline)

Module parameter originates in:	X-UNC