VCS Module

VMD0016

Methods for Stratification of the Project Area (X-STR)

Version 1.~~1~~2

~~9 March 2015~~14 February 2017

Sectoral Scope 14

Module developed by:

Revision to include project activities on peatlands (version 1.1 of this module) prepared by Permian Global, Silvestrum and Greifswald University

Revision to include tidal wetland restoration and conservation activities (version 1.2 of this module) prepared by Silvestrum Climate Associates, University of Maryland and Restore America's Estuaries

Table of Contents

1 SOURCE

This module is one of numerous modules that constitute the VCS methodology *VM0007 REDD+ Methodology Framework (REDD+ -MF)*.

This module uses the latest version of following methodology:

- *VM0006 Methodology for Carbon Accounting for Mosaic and Landscape-scale REDD Projects*

2 SUMMARY DESCRIPTION OF THE MODULE

This module provides guidance on stratifying the project area into discrete, relatively homogeneous units to improve accuracy and precision of carbon stock, carbon stock change and GHG emission estimates.

Different stratifications may be required for the baseline and project scenarios to achieve optimal accuracy of the estimates of net GHG emissions or removals. The procedures that are described in this module are:

Stratification of aboveground biomass

Differentiation of peatland from non-peatland

Stratification of the peatland area into discrete units of relatively homogenous emission characteristics

Stratification of the peatland area based on peat thickness

Establishment of a buffer zone

In the equations used in the accompanying modules, the suffix *i* is used to represent a stratum and the suffix *M* for the total number of strata (M_{WPS} for the project scenario and M_{BSL} for the baseline scenario).

3 DEFINITIONS

In addition to the definitions set out in the VCS document *Program Definitions* and VCS methodology *VM0007 REDD+ MF*, the following definitions apply to this module:

Definitions are set out in in VCS document *Program Definitions*, and methodology *REDD-MF*. This module does not set out any further definitions.**Domed Peatland**
Peat landform shaped like a dome, commonly depending on rainwater alone, or on artesian water. Peat depth can be expected to increase from the edges towards the center of the dome.

Acronyms

REDD Reducing Emissions from Deforestation and forest Degradation
RDP Rewetting of Drained Peatland
CUPP Conservation of Undrained or Partially drained Peatland
DTM Digitatol Terrain Model

VCS Verified Carbon Standard
WRC Wetlands Restoration and Conservation
GHG Greenhouse Gas
PDT Peat Depletion Time
SOC Soil Organic Carbon

4 APPLICABILITY

Any module referencing strata *i* must be used in combination with this module.

In case of REDD, aboveground biomass stratification is only used for pre-deforestation forest classes, and strata are the same in the baseline and the project scenario. Post-deforestation land uses are not stratified. Instead, average post-deforestation stock values (e.g., simple or historical area-weighted approaches are used, as per Module *BL-UP*).

For peatland rewetting and conservation project activities this module must be used to delineate non-peat versus peat and to stratify the peat according to peat depth and soil emission characteristics, unless it can be demonstrated that the expected emissions from the soil organic carbon pool or change in the soil organic carbon pool in the project scenario is *de minimis*,

In the case of ~~peatland rewetting and conservation~~WRC project activities, the project boundary must be designed such that the negative effect of drainage activities that occur outside the project area on the project GHG benefits are minimized.

5 PROCEDURES

The project area may be stratified *ex ante*, and this stratification may be revised *ex post* for monitoring purposes. Established strata may be merged if reasons for their establishment have disappeared or have proven irrelevant to key variables for estimating net GHG emissions or removals.

A map displaying the final delineation of strata must be included in the project description. Areas of individual strata naturally sum to the total project area; any discrepancies must be reconciled.

5.1 Stratification of Above ~~G~~ground Biomass in REDD Project Activities

Pre-stratification (prior to inventory) of the project area is not required, however, pre-stratification may serve to avoid requirements for post measurement stratification later (below). It is not expected that the project proponent will begin with high resolution, spatially explicit, biomass measurement information for the project area and leakage belt. Thus, it is acceptable practice to base strata on ancillary data that can serve as a proxy for potential biomass classes (e.g., vegetation class maps, interpretation of aerial photographs or high resolution satellite imagery; see Module *BL-UP*). The areas of strata delineated prior to allocation of inventory plots using stratified sampling are known exactly and require no accuracy assessment.

At the project start and whenever biomass stocks are re-measured (i.e., at least every 10 years), the project proponent must demonstrate after inventory that within the project area there are no unidentified (i.e., not previously stratified) discrete clusters of sample plots/points representing >10% of samples in the project area that consistently differ (i.e., each sample plot/point estimate) from the overall project mean by ±20%. In the event that such a cluster of points is identified, a new stratum will be delineated. Area limits of the new stratum, encompassing the cluster, can be determined on the basis of existing vegetation class maps, interpretation of aerial photographs or high-resolution satellite imagery.

Stratification of Aboveground Biomass Using Remote Sensing

When using remote sensing, data must be georeferenced into a common geodetic system, for example using the UTM system using best-practice methods in remote sensing (see eg, Congalton 1991; Congalton *et al*., 2008)[1]. Semi-automated image classification approaches may be applied. Strata must be validated by reference data collected in the field, other official documentation, or from recent independent higher resolution remote sensing imagery. Ancillary GIS data may be used to assist the delineation of biomass classes (e.g., elevation, vegetation maps)

5.2 Differentiation of Peatland from Non Non-Peatland

Available maps, field observations, remote sensing data and other official documentation may be used to differentiate peatland from non-peatland and thus to estimate the total area of peat within the project area or proxy areas (*Ap*). The most recent available (peat) maps must be used. Creation of a map based on field or remote sensing data can be carried out in combination with the creation of the peat depth map, following procedures outlined below.

Stratification of the Peatland Area in Discrete Units of Relatively Homogenous Emission Characteristics

GHG emissions from the peat soil are assessed by proxies. Proxies include land-use type, land management practices, vegetation cover, micro-topography, water table depth, and subsidence rate.

The area of channels and ditches ($A_{ditch\text{-}WPS}$ for the project scenario and $A_{ditch\text{-}BSL}$ for the baseline scenario) must be quantified and expressed as a portion of the project area (cf. IPCC 2013 – Section 2.2.2.1), but do not have to be explicitly mapped. Emissions from shallow peat strata (see 4 (a) below), where the entire peat layer is above the water table depth, are determined by peat depth rather than water table depth and must be treated accordingly. Similarly, strata that have alternating peat and mineral soil layers above the water table must be treated separately, e.g., by conservatively treating them as shallow peat strata defined by the thickness of the top layer of peat. Both shallow and interlayered strata can conservatively be treated as mineral soil strata. If strata are defined on the basis of water table depth, it is allowed allowable to define emission classes (e.g., ~0 cm defining a level of zero emissions, a deep water table defining the high end of emissions, and arbitrary classes in between). Water table depth data can be derived from measurements (see Module *M-PEAT* for procedures), from (local) expert judgment or land management handbooks, or from proxies, like canal water levels, distance to canals or land cover, land management practices and vegetation. Also, hydrological modeling may be used to derive spatially and temporally specific estimates of water table depths.

[1] See e.g., Congalton 1991; Congalton *et al*., 2008

5.3 Stratification of the Peatland Area, Based on Peat Thickness

5.3.1 General

Stratification of the project area by peat thickness, as required, will be determined as follows:

1. Procedures for the determination of peat thickness in domed peatland are provided in Section 5.3.2 below.

~~1.~~2. When in more than 5% of the project area peat is absent or the thickness of the peat is below a threshold value (e.g., 10 cm in temperate peatland or 50 cm in tropical peatland); the peat depth map only needs to distinguish where peat thickness exceeds this threshold. It is conservative to treat shallow peat strata as mineral soil strata.

~~2.~~3. When using a conservative (high) value for subsidence rates, ~~in more than 5% of the project area~~ if less peat is available at t = 100 years in more than 5% of the project area in the project scenario than in the same strata in the baseline scenario, the peat thickness map only needs to distinguish these strata.

~~3.~~4. When using a conservative (high) value for subsidence rates, if the project crediting period exceeds the peat depletion time (PDT) in the baseline scenario in more than 5% of the project area, ~~the Crediting Period exceeds the peat depletion time (PDT);~~ the peat thickness map must distinguish ~~with a resolution of~~ 10 cm (50 cm in domed peatland)those strata where peat will be depleted within the Crediting Period. The project proponent must demonstrate that the resolution used in mapping results in a conservative assessment (i.e., it tends to overestimate strata that will be depleted), for example, by assessing variation in peat depth near the critical depth through multiple corings at close distance or by assuming a default conservative error (e.g., of 10 cm in moss or sedge peat or 50 cm in (tropical) wood peat with coarse woody remnants). Peat strata that will be depleted can be further stratified according to their peat depletion time. Areas where peat will not be depleted need not be further stratified.

No stratification on the basis of peat thickness is required if the peat thickness in 95% or more of the project area exceeds the required minimum peat depth for all of the above conditions.

Areas at the project start date with a peat layer shallower than required by the adopted definition of peatland may be included if those areas are connected with others that meet the definition. Isolated pockets that do not meet the definition may not be included.

Stratification of peat depth must be based on existing peat depth maps and/or on field assessment and/or in combination with remote sensing data. Interpolation techniques, such as Kriging, can be used to derive conservative peat depth maps. When using existing peat depth maps or data, these must be corrected conservatively for peat subsidence. If after correction, strata exceed the required minimum peat depth by less than 50 cm, these strata must be verified through field observations, e.g., using a peat auger, following the procedures outlined below.

To create a peat depth map, depth measurements must be conducted in a systematic way along transects that cover the peatland. Starting from the margin (or boundary) of the peatland, the initial distance between depth observations along transects must not be greater than 100 m with a depth accuracy of at least 10 cm. Distance between transects must be 200 m at maximum. When two subsequent depth observations along a transect fulfill the required depth criteria by a margin of at least 50 cm, the distance between transects and observation points can be raised to 500 m (4 measurements per km[2]). Transects must cross the entire terrain of the peatland and must be initiated from opposed margins. If transects cross areas of mineral soil that are present inside a contiguous area of peat, transects departing from these areas of mineral soil must also have an initial distance between depth observations of not greater than 100 m. Peat depth maps must be based on peat depth measurements in combination with interpolation techniques to derive conservative peat depth maps of the required accuracy.

In case shallow peat areas are conservatively neglected, it is sufficient to conduct depth measurements that cover the peatland in a systematic way, with at least 4 measurement points per km^2 or separated by a distance of 500 m.

The area of channels and ditches must be quantified and treated as separate strata. Methane (CH_4) emissions from these channels and ditches will not increase in the project scenario compared to the baseline scenario[2] and, therefore, CH_4 emissions from these channels and ditches can be excluded from GHG accounting.

5.3.2 Peat Thickness in Domed Peatland

Procedures for domed peatland supersede the above general procedures.

In domed tropical peat swamp, stratification of peat depth must use a thickness accuracy of at least 50 cm.[3]

In domed peatlands height above datum is a good measure of peat depth.[4] A height model or DTM can be established using field methods or remote sensing. Remote sensing-based models can be established using STRM (Shuttle Radar Topography Mission) data or LiDAR data, for example. To obtain soil surface height, these data must be corrected for vegetation height. The forest canopy height for different strata of peat swamp forests can be derived from literature or by comparing vegetation height to terrain height on vegetated and non-vegetated areas or through representative field measurements of canopy height or a combination of these. When using LiDAR data of sufficient point density, the point cloud can be filtered to separate surface and canopy points. Applicability of forest height data must be justified, accuracy indicated, and conservativeness demonstrated.

The height model must be combined with data from peat corings to generate a spatially explicit map of peat strata that fulfill the above requirements. The required peat depth at each sampling location must be determined with a resolution of at least 0.5 m using a peat corer or auger (such as an Eijkelkamp corer).[5] Peat coring locations must be selected using representative random sampling or systematic sampling. It is acceptable to conduct corings along transects that run perpendicular to the perimeter of the peat dome. Sampling intervals must range from 500 100 to 1500 m depending on the size of the peat dome, terrain accessibility, observed peat thickness and the observed slope in subsequent peat thickness assessments along the transect.

2 Couwenberg *et al.* 2011
3 In the drained baseline situation peat subsidence typically amounts to up to 5 cm yr^{-1}; the 50 cm accuracy criterion thus relates to the minimum monitoring interval of 10 years; in the project scenario subsidence rates will be considerably lower (ideally 0 cm) and the 50 cm accuracy criterion will amount to <5% error on the 100-year permanence criterion.
4 Jaenicke *et al*. 2008
5 Peat sampling depths described above will differ from those in moss/sedge peat and peat containing coarse wood.

If observed peat thickness fulfills the depth criterion by >50 cm ~~larger than required~~ for two subsequent corings along a transect and if the height model indicates a slope ≥0 in the same direction, then it is allowed to assume peat thickness will remain sufficient to fulfill peat depletion and permanence criteria further along the transect until the slope becomes <0.

A cross-section of the dome can be established using corings along the same transect but starting from the opposite margin and following the same rules. A spatially explicit peat depth map can be attained from the peat depth data using spatial interpolation, such as Kriging.

In highly inaccessible areas, the peat surface elevation provides a conservative estimate of peat thickness[6] ~~(cf. Jaenicke *et al*. 2008)~~ and peat corings are not required.

5.4 Area of Peatland Eligible for Crediting

The maximum eligible quantity of GHG emission reductions by rewetting is limited to the difference between the remaining peat carbon stock in the project and baseline scenarios after 100 years (total stock approach), or the difference in cumulative carbon loss in both scenarios over a period of 100 years since project start (stock loss approach). If a significant difference at the 100-year mark cannot be demonstrated, strata are not eligible for carbon crediting. The assessment must be executed *ex ante*, using conservative parameters.

5.4.1 Total Stock Approach

The difference between peat carbon stock in the project scenario and baseline scenario at $t = 100$ is estimated as:

$$C_{WPS-BSL,t100} = \sum_{i=0}^{M_{WPS}} \left(C_{WPS,i,t100} \times A_{WPS,i} \right) - \sum_{i=0}^{M_{BSL}} \left(C_{BSL,i,t100} \times A_{BSL,i} \right) \quad (1)$$

For organic soil:

$$C_{WPS,i,t100} = Depth_{peat\text{-}WPS,i,\ t100} \times C_{vol\_lower,WPS} \times 10 \quad (2)$$

$$C_{BSL,i,t100} = Depth_{peat\text{-}BSL,i,\ t100} \times C_{vol\_lower,BSL} \times 10 \quad (3)$$

$$Depth_{peat-BSL,i,t100} = Depth_{peat-BSL,1,t0} - Sub_{initial-BSL,i} - \sum_{t=1}^{t=100} Rate_{peatloss-BSL,i,t} \quad (4)$$

$$Depth_{peat-WPS,i,t100} = Depth_{peat-WPS,1,t0} - \sum_{t=1}^{t=100} Rate_{peatloss-WPS,i,t} \quad (5)$$

For mineral soil:

[6] cf. Jaenicke *et al*. 2008

$$C_{BSL,i,t100} = C_{i,t0} - \sum_{t=1}^{t=100} Rate_{Closs-BSL,i,t} \qquad (6)$$

$$C_{WPS,i,t100} = C_{i,t0} - \sum_{t=1}^{t=100} Rate_{Closs-WPS,i,t} \qquad (7)$$

$$C_{i,t0} = Depth_{soil,i,t0} \times VC \times 10 \qquad (8)$$

Where:

$C_{WPS\text{-}BSL,i,t100}$ Difference between ~~peat~~ soil organic carbon stock in the project scenario and baseline scenario in peat depth stratum *i* at *t* = 100 (t C ha^{-1})

$C_{WPS,i,t100}$ ~~Peat~~ Soil organic carbon stock in the project scenario in peat depth stratum *i* at *t* = 100 (t C ha^{-1})

$C_{BSL,i,t100}$ ~~Peat~~ Soil organic carbon stock in the baseline scenario in peat depth stratum *i* at *t* = 100 (t C ha^{-1})

$A_{WPS,i}$ Area of project stratum *i* (ha)

$A_{BSL,i}$ Area of baseline stratum *i* (ha)

$Depth_{peat\text{-}BSL,i,t100}$ Average peat depth in the baseline scenario in stratum *i* at *t* = 100 (m)

$Depth_{peat\text{-}WPS,i,t100}$ Average peat depth in the project scenario in stratum *i* at *t* = 100 (m)

$Depth_{peat\text{-}BSL,i,t0}$ Average peat depth in the baseline scenario in stratum *i* at project start (m)

$Depth_{peat\text{-}WPS,i,t0}$ Average peat depth in the project scenario in stratum *i* at project start (m)

$Depth_{soil,i,t0}$ Mineral soil depth in stratum *i* at the project start date (m)

$Sub_{initial\text{-}BSL,i}$ Subsidence in the initial years after drainage in stratum *i*, deemed 0 for RDP projects (m)

$Rate_{peatloss\text{-}BSL,i,t}$ Rate of peat loss due to subsidence and fire in the baseline scenario in stratum *i* in year *t*; a conservative (high) value may be applied that remains constant over time; Subsidence in the initial years after drainage is not included in this rate (m yr^{-1})

$Rate_{peatloss\text{-}WPS,i,t}$ Rate of peat loss due to subsidence and fire in the project scenario in stratum *i* in year *t*; alternatively, a conservative (low) value may be applied that remains constant over time (m yr^{-1})

$Rate_{Closs\text{-}BSL,i,t}$ Rate of organic carbon loss in mineral soil due to oxidation in the baseline scenario in stratum *i* in year *t* (t C ha^{-1} yr^{-1})

$Rate_{Closs\text{-}WPS,i,t}$ Rate of organic carbon loss in mineral soil due to oxidation in the project scenario in stratum *i* in year *t* (t C ha^{-1} yr^{-1}). This value is conservatively set to zero as loss rates are likely to be negative. This parameter must be reassessed when the baseline is reassessed.

$C_{vol\_lower,WPS}$ Volumetric carbon content of the peat below the water table in the project scenario; in case of RDP projects, this is the same as $C_{vol\_lower,BSL}$ (kg C m^{-3})

$C_{vol\_lower,BSL}$ Volumetric carbon content of the peat below the water table in the baseline scenario (kg C m^{-3})

$C_{i,t0}$ Soil organic carbon stock in mineral soil in stratum *i* at the project start date (t C ha^{-1})

VC Volumetric organic carbon content in organic or mineral soil (kg C m^{-3})

t_{100} 100 years since project start

10 Conversion from kg m^{-2} to t ha^{-1}

If a conservative constant subsidence rate or carbon loss is applied, a possible negative outcome is substituted by zero.

~~The volumetric carbon content in peat can be taken from own measurements within the project area or from literature involving the project or areas of equal vegetation cover and water table depth. In case of CUPP projects, when initial high subsidence rates are expected, $VC_{peat,BSL}$ must be derived from a peatland area under the baseline land use that has undergone this initial subsidence, not from the peat in the project area itself. In the case of RDP projects and CUPP projects where initial high subsidence rates have already occurred, $Sub_{initial\text{-}BSL,i}$ is zero and $VC_{peat,WPS}$ and $VC_{peat,BSL}$ are treated as identical and can be derived from field measurements in the project area (see module *M-PEAT*). In case of CUPP projects, $Sub_{initial}$ must be estimated from literature data pertaining to peatland areas in the same region that underwent equal land use development as projected for the baseline scenario. $Rate_{peatloss}$ for the project scenario must be determined by measurements in the project area; $Rate_{peatloss}$ constitutes the sum of $Rate_{subs}$ and $D_{peatburn}$ (see module *M-PEAT*), for the baseline scenario, it must be derived either from measurements in areas under the same land use or from literature pertaining to such areas. $C_{WPS,i,t100}$ must be adjusted for leakage (see module *LK-ECO*).~~

The difference between ~~peat~~ carbon stock in the project scenario and baseline scenario at $t = 100$ ($C_{WPS\text{-}BSL,t100}$) is significant if:

$$\sum_{i=0}^{M_{WPS}} \left(C_{WPS,i,t100} \times A_{WPS,i}\right) \geq 1.05 \times \sum_{i=0}^{M_{BSL}} \left(C_{BSL,i,t100} \times A_{BSL,i}\right) \qquad (9)$$

Where:

$C_{WPS,i,t100}$	~~Peat~~ Soil organic carbon stock in the project scenario in peat depth stratum *i* at $t = 100$ (t C ha^{-1})
$C_{BSL,i,t100}$	~~Peat~~ Soil organic carbon stock in the baseline scenario in peat depth stratum *i* at $t = 100$ (t C ha^{-1})
$A_{WPS,i}$	Area of project stratum *i* (ha)
$A_{BSL,i}$	Area of baseline stratum *i* (ha)

Additional Procedures for Peatland

The volumetric carbon content in peat can be taken from one's own measurements within the project area or from literature involving the project or areas of equal vegetation cover and water table depth. In case of CUPP projects, when initial high subsidence rates are expected, $VC_{peat,BSL}$ must be derived from a peatland area under the baseline land use that has undergone this initial subsidence, not from the peat in the project area itself. In the case of RDP projects and CUPP projects where initial high subsidence rates have already occurred, $Sub_{initial\text{-}BSL,i}$ is zero and $VC_{peat,WPS}$ and $VC_{peat,BSL}$ are treated as identical and can be derived from field measurements in the project area (see Module *M-PEAT*). In case of CUPP projects, $Sub_{initial}$ must be estimated from literature data pertaining to peatland areas in the same region that underwent equal land use development as projected for the baseline scenario. $Rate_{peatloss}$ for the project scenario must be determined by measurements in the project area; $Rate_{peatloss}$ constitutes the sum of $Rate_{subs}$ and $D_{peatburn}$ (see Module *M-PEAT*), for the baseline scenario, it must be derived either from measurements in areas under the same land use or from literature pertaining to such areas. $C_{WPS,i,t100}$ must be adjusted for leakage (see Module *LK-ECO*).

If not measured directly, $Rate_{peatloss,i,t}$ can be derived as follows:

$$Rate_{peatloss,i,t} = \frac{\sum_{i=1}^{M}(E_{peatsoil,i,t} + E_{peatburn,i,t})}{A_i \times C_{vol\_lower,i,t}} \times 10 \times \frac{12}{44} \quad (10)$$

Where:

$Rate_{peatloss,i,t}$	Rate of peat loss due to subsidence and fire in stratum *i* in year *t* (m yr^{-1})
$E_{peatsoil,CO2,i,t}$	CO_2 emissions from the peat soil in stratum *i* in year *t* (t CO_2e yr^{-1})
$E_{peatburn,CO2,,i,t}$	CO_2 emissions from burning of peat in stratum *i* in year *t* (t CO_2e yr^{-1})
A_i	Area of stratum *i* in baseline or project scenario (ha)
$C_{vol\_lower,i,t}$	Volumetric carbon content of the peat below the water table in stratum *i* in year *t* (kg C m^{-3})
12/44	Factor to change from t CO_2e yr^{-1} to t C yr^{-1}
10	Conversion from kg m^{-2} to t ha^{-1}

5.4.2 Stock Loss Approach

As $Depth_{peat\text{-}BSL,i,t0} = Depth_{peat\text{-}WPS,i,t0}$, the assessment can also be based on cumulative subsidence up to $t = 100$ as follows:

$$C_{WPS-BSL,t100} = \sum_{i=1}^{M_{BSL}}\left(C_{loss-BSL,i,t100} \times A_{BSL,i}\right) - \sum_{i=1}^{M_{WPS}}\left(C_{loss-WPS,i,t100} \times A_{WPS,i}\right) \quad (11)$$

For organic soil:

$$C_{WPS-BSL,t100} = \sum_{i=0}^{M_{BSL}}\left(C_{peatloss-BSL,i,t100} \times A_{BSL,i}\right) - \sum_{i=0}^{M_{WPS}}\left(C_{peatloss-WPS,i,t100} \times A_{WPS,i}\right) \quad (12)$$

$$C_{loss-BSL,i,t100} = 10 \times \left(\sum_{t=1}^{t100}\left(Rate_{peatloss-BSL,i,t} \times C_{vol\_lower}\right)\right)$$

$$C_{peatloss-BSL,i,t100} = 10 \times \left(\sum_{t=1}^{t100}\left(Rate_{peatloss-BSL,i,t} \times C_{vol\_lower}\right)\right) \quad (13)$$

$$C_{loss-WPS,i,t100} = 10 \times \left(\sum_{t=1}^{t100}\left(Rate_{peatloss-WPS,i,t} \times C_{vol\_lower}\right)\right)$$

$$C_{peatloss-WPS,i,t100} = 10 \times \left(\sum_{t=1}^{t100}\left(Rate_{peatloss-WPS,i,t} \times C_{vol\_lower}\right)\right) \quad (14)$$

For mineral soil:

$$C_{loss-BSL,i,t100} = 10 \times \sum_{t=1}^{100}\left(Rate_{Closs-BSL,i,t} \times VC\right) \quad (15)$$

$$C_{loss-WPS,i,t100} = 10 \times \sum_{t=1}^{100} \left(Rate_{Closs-WPS,i,t} \times VC \right) \qquad (16)$$

Where:

$C_{WPS-BSL,i,t100}$	Difference between peat carbon stock in the project scenario and baseline scenario in subsidence stratum *i* at $t = 100$ (t C ha^{-1})
~~$C_{peatloss-BSL,i,t100}$~~	~~Cumulative peat carbon loss due to subsidence and fire in the baseline scenario in subsidence stratum *i* at t=100 (t C ha^{-1})~~
~~$C_{peatloss-WPS,i,t100}$~~	~~Cumulative peat carbon loss due to subsidence and fire in the project scenario in subsidence stratum *i* at t=100 (t C ha^{-1})~~
$C_{loss-BSL,i,t100}$	Cumulative soil organic carbon loss (in peatlands: due to subsidence and fire) in the baseline scenario in stratum *i* at $t = 100$ (t C ha^{-1})
$C_{loss-WPS,i,t100}$	Cumulative soil organic carbon loss (in peatlands: due to subsidence and fire) in the project scenario in stratum *i* at $t = 100$ (t C ha^{-1})
$A_{WPS,i}$	Area of project stratum *i* (ha)
$A_{BSL,i}$	Area of baseline stratum *i* (ha)
$Rate_{peatloss-BSL,i,t}$	Rate of peat loss due to subsidence and fire in the baseline scenario in stratum *i* in year *t*; alternatively, a conservative (low) value may be applied that remains constant over time. Subsidence in the initial years after drainage is not included in this rate (m yr^{-1})
$Rate_{peatloss-WPS,i,t}$	Rate of peat loss due to subsidence and fire in the project scenario in stratum *i* in year *t*; alternatively, a conservative (high) value may be applied that remains constant over time (m yr^{-1})
$Rate_{Closs-BSL,i,t}$	Rate of organic carbon loss in mineral soil due to oxidation in the baseline scenario in stratum *i* in year *t* (t C ha^{-1} yr^{-1})
$Rate_{Closs-WPS,i,t}$	Rate of organic carbon loss in mineral soil due to oxidation in the project scenario in stratum *i* in year *t* (t C ha^{-1} yr^{-1}). This value is conservatively set to zero as loss rates are likely to be negative. This parameter must be reassessed when the baseline is reassessed.
C_{vol_lower}	Volumetric carbon content of the peat below the water table in the baseline scenario (kg C m^{-3})
t_{100}	100 years after project start
10	Conversion from kg m^{-2} to t ha^{-1}

The difference between ~~peat~~ soil organic carbon stock in the project scenario and baseline scenario at $t = 100$ ($C_{WPS-BSL,t100}$) is significant if:

~~$$\sum_{i=0}^{M_{BSL}} \left(C_{peatloss-BSL,i,t100} \times A_{BSL,i} \right) \geq 1.05 \times \sum_{i=0}^{M_{WPS}} \left(C_{peatloss-WPS,i,t100} \times A_{WPS,i} \right)$$~~

$$\sum_{i=1}^{M_{BSL}} \left(C_{loss-BSL,i,t100} \times A_{BSL,i} \right) \geq 1.05 \times \sum_{i=1}^{M_{WPS}} \left(C_{loss-WPS,i,t100} \times A_{WPS,i} \right) \qquad (17)$$

Where:

~~$C_{peatloss-BSL,i,t100}$ Cumulative peat carbon loss due to subsidence and fire in the baseline scenario in subsidence stratum *i* at *t*=100 (t C ha^{-1})~~

~~$C_{peatloss-WPS,i,t100}$ Cumulative peat carbon loss due to subsidence and fire in the project scenario in subsidence stratum *i* at *t*=100 (t C ha^{-1})~~

$C_{loss-BSL,i,t100}$	Cumulative soil organic carbon loss (in peatlands: due to subsidence and fire) in the baseline scenario in stratum *i* at *t* = 100 (t C ha^{-1})
$C_{loss-WPS,i,t100}$	Cumulative soil organic carbon loss (in peatlands: due to subsidence and fire) in the project scenario in stratum *i* at *t* = 100 (t C ha^{-1})
$A_{WPS,i}$	Area of project stratum *i* (ha)
$A_{BSL,i}$	Area of baseline stratum *i* (ha)

Additional Procedures for Peatland

When $Rate_{peatloss}$ is not assessed directly,

$$C_{peatloss,i,t100} = \sum_{t=1}^{t100} E_{peatsoil,CO2,i,t} + E_{peatburn,CO2,i,t} \times \frac{12}{44} \quad (18)$$

Where:

$C_{peatloss,i,t100}$	Cumulative peat carbon loss due to subsidence and fire in subsidence stratum *i* at *t* = 100 (t C ha^{-1})
$E_{peatsoil,CO2,i,t}$	CO_2 emissions from the peat soil in stratum *i* in year *t* (t CO_2e yr^{-1})
$E_{peatburn,CO2,i,t}$	CO_2 emissions from burning of peat in stratum *i* in year *t* (t CO_2e yr^{-1})
t_{100}	100 years after project start
12/44	Factor to change from t CO_2e yr^{-1} to t C yr^{-1}

High rates of subsidence in the initial years after drainage are not separately taken into account, as carbon losses are comparable to later years and the main effect is on total peat depth, which is not considered in this approach. Using short-term or historic subsidence rates for the entire period of 100 years is conservative since subsidence rates are likely to decline over time.[7]

5.5 Stratification According to Peat Depletion Time (PDT)

Drained peat is subject to oxidation and subsidence and areas with peat at *t* = 0 may lose all peat before the end of the crediting period. The time at which all peat has disappeared is referred to as the PDT. Peat depletion may be accelerated by peat fires. The PDT for a stratum in the baseline scenario equals the period during which the project can claim emission reductions from rewetting and is, per stratum *i*, estimated at the project start date as follows:

$$t_{PDT-BSL,i} = Depth_{peat-BSL,i} \,/\, Rate_{peatloss-BSL,i} \quad (19)$$

Where:

$t_{PDT-BSL,i}$	Peat depletion time in the baseline scenario in stratum *i* in years elapsed since the project start (yr)
$Depth_{peat-BSL,i}$	Average peat depth in the baseline scenario in stratum *i* at project start (m)

[7] Stephens *et al.* 1984

$Rate_{peatloss-BSL,i}$	Rate of peat loss due to subsidence and fire in the baseline scenario in stratum *i*; a conservative (high) value may be applied (m yr[-1])
i	1, 2, 3 …M_{BSL} strata in the baseline scenario

Peat depth must be derived as described in this module. Depth of burn scars is assessed following procedures in Module *M-PEAT*.

Note that $Rate_{peatloss-BSL,i}$ is not used to determine baseline emissions but solely to determine $t_{PDT-BSL,i}$.

If $t_{PDT-BSL,i}$ falls within the Crediting Period, subsequent organic carbon loss from remaining mineral soil may be estimated as well using the procedure for SDT in Section 5.6.

5.6 Stratification According to Soil organic carbon Depletion Time (SDT)

WRC project activities that do not quantify reductions of emissions of baseline emissions (i.e., those which limit their accounting to GHG removals in biomass and/or soil) do not require the estimation of SDT.

SDT for a stratum in the baseline scenario equals the period during which the project is eligible to claim emission reductions from restoration, and is estimated at the project start date for each stratum *i* as follows.

For strata with eroded soils:

$$t_{SDT-BSL,i} = 5 \text{ years} \quad (20)$$

Where:

$t_{SDT-BSL,i}$ SDT in the baseline scenario in stratum *i* (in years elapsed since the project start date) (yr)

For strata with soils exposed to an aerobic environment through excavation or drainage:

$$t_{SDT-BSL,i} = t_{0,i} - t_{steadystate,i} \quad (21)$$

Where:

$t_{SDT-BSL,i}$	SDT in the baseline scenario in stratum *i* (in years elapsed since the project start date) (yr)
$t_{0,i}$	The project start date, in stratum *i*, or when soils are exposed to an aerobic environment (yr)
$t_{steadystate,i}$	The year when the soil carbon mass has reached steady state equilibrium, in stratum *i*, in mineral soils (yr)
i	1, 2, 3 …M_{BSL} strata in the baseline scenario

The project proponent must determine the depth ($Depth_{soil,i,t0}$ in Equation 8) over which $t_{steadystate,i}$ is determined. Note that a shallower depth will lead to a shorter, and more conservative, SDT. Only where SDT is determined, reductions of baseline emissions from mineral soil may be claimed.

Estimates of $t_{steadystate,i}$ following the aerobic exposure event must account for the tendency of organic carbon concentrations to approach steady-state equilibrium in mineral soils. For this reason, a complete loss of soil organic carbon may not occur in mineral soils. This steady-state equilibrium must be determined conservatively.

In case of alternating mineral and organic horizons, $t_{steadystate,i}$ may be determined for all individual horizons. This also applies to cases where an organic surface layer of less than 10 cm exists or in cases where the soil is classified as organic but its organic matter depletion is expected within the Crediting Period and oxidation of organic matter in an underlying mineral soil may occur within this period.

With respect to the estimation of SDT, the accretion of sediment in the baseline scenario is conservatively excluded.

5.7 Establishment of a Buffer Zone

Under the applicability condition of this methodology, the project boundary must be designed such that the negative effect of drainage activities that occur outside the project area on the project GHG benefits are minimized (eg, enhanced drainage, groundwater extraction, and changing water supply). This can be achieved either by an appropriate design (eg, by establishing an impermeable dam) or by a buffer zone within the project boundary. This buffer zone, if employed, must be mapped. The buffer zone must be determined on the basis of quantitative hydrological modeling, literature references or expert judgment. Procedures outlined ~~under 1 – 4~~in Sections 5.1 – 5.6 above also apply to the buffer zone. Alternatively, the buffer zone can conservatively be omitted from the accounting.

Procedures for buffer zones to avoid ecological leakage are provided in Module *LK-ECO*.

5.8 Project Boundaries and Effects of Sea Level Rise

When defining geographic project boundaries and strata, the project proponent must consider expected relative sea-level rise and the potential for expanding the project area landward to account for wetland migration, inundation and erosion. The project area cannot be changed during the project crediting period.

For both the baseline and project scenarios, the project proponent must provide a projection of relative sea-level rise within the project area based on IPCC regional forecasts or peer-reviewed literature applicable to the region. In addition, the project proponent may also utilize expert judgment.[8] Global average sea-level rise scenarios are not suitable for determining the changes in wetland boundaries. Therefore, if used, IPCC most-likely global sea-level rise scenarios must be appropriately downscaled to regional conditions that include vertical land movements, such as subsidence.

Whether degradation occurs in the baseline scenario, or conservation or restoration occurs in the project scenario, the assessment of potential wetland migration, inundation and erosion with respect to projected sea-level rise must account for topographical slope, land use and management, sediment supply and tidal range. The assessment may use published data from the literature relevant to the project area, expert judgment, or both.

[8] Requirements for expert judgment are provided in *REDD+ MF*

When assessing the potential for tidal wetlands to migrate horizontally, one must consider the topography of the adjacent land and any migration barriers that may exist. In general, and on coastlines where wetland migration is unimpaired by infrastructure, concave-up slopes may cause 'coastal squeeze', while straight or convex-up gradients are more likely to provide the space required for lateral movement.

The potential for tidal wetlands to rise vertically with sea-level rise is sensitive to suspended sediment loads in the system. A sediment load of >300 mg per liter has been found to balance high-end IPCC scenarios for sea-level rise.[9] It has been suggested that the findings of Orr et al. 2003 from the San Francisco Bay could be used elsewhere.[10] At 250 mg per liter, sea-level rise of 15 mm is balanced at a tidal range of 1 m or greater.[11] Therefore, for marshes with a tidal range greater than 1 meter, the project proponent may use >300 mg per liter as a sediment load threshold, above which wetlands are not predicted to be submerged. The project proponent may use lower threshold values for tidal range and sediment load where justified. The vulnerability of tidal wetlands to sea-level rise and conversion to open water is also related to tidal range. In general, the most vulnerable tidal wetlands are those in areas with a small tidal range, those with elevations low in the tidal frame, and those in locations with low suspended-sediment loads.

Alternatively, in the project scenario the project proponent may conservatively assume that part of the wetland within the project area erodes, and does not migrate. See Section 5.3.3 in Module *M-TW* for procedures to estimate CO_2 emissions from eroded soil. In the baseline scenario, the project proponent may conservatively assume that part of the project area submerges, with cessation of GHG removal from the atmosphere as a consequence. If the project is not claiming emissions due to erosion in the baseline scenario, the project proponent may conservatively assume that part of the project area erodes. For areas that submerge without erosion, the loss of SOC may be assumed to be insignificant in both the baseline and project scenarios.

The projection of wetland boundaries within the project area must be presented in maps delineating these boundaries from the project start date until the end of the project crediting period, at intervals appropriate to the rate of change due to sea-level rise, and at $t = 100$.

Procedures for accounting for project area submergence due to relative sea-level rise are provided in the Module *BL-TW*.

5.9 Seagrass Meadows

Given the tendency of seagrasses to respond differently under different light and depth regimes, the project proponent may differentiate between seagrass meadow sections that occur at different depths, given discrete, or relatively abrupt, bathymetric and substrate changes. The project proponent must determine whether each project area is eroding or accreting in the baseline scenario if they wish to receive credit for conservation projects.

For seagrass meadow restoration projects in areas with existing seagrass meadows, the project proponent must quantify the percentage of meadow expansion that can be attributed to the restoration effort but that is not the result of direct planting or seeding. Existing meadows (unless smaller in area

[9] French 2006 and Morris *et al*. 2012~~Orr *et al*. 2003, Stralsburg *et al*. 2011~~
[10] Orr *et al*. 2003, Stralberg *et al*. 2011
[11] French 2006

than 5 percent of the total project area) must be excluded from the calculation of project emissions, even in cases where the restored meadow enhances carbon sequestration rates in existing meadows.

New seagrass meadows that result from natural expansion must be contiguous with restored meadow plots in order to be included in project accounting, unless the project proponent demonstrates that non-contiguous meadow patches originated from restored meadow seeds. This may be performed via genetic testing, or estimated as a percentage of new meadow in non-contiguous plots and observed no less than four years after the project start date. This percentage must not exceed the proportion of restored meadow area relative to the total extent of seagrass meadow area, and the project proponent must demonstrate the feasibility of current-borne seed dispersal from the restored meadow. In cases where a restored meadow coalesces with an existing meadow(s), the project proponent must delineate the line at which the two meadows are joined. The project proponent may use either aerial observations showing meadow extent or direct field observations.

For seagrass meadow conservation projects, the project proponent must also quantify rates of bathymetric change in the baseline scenario within the project area resulting from erosion or accretion. If different areas within the project area are eroding and accreting, projects must stratify the project area to differentiate between different relative bathymetric changes over time. Projects may receive credit for maintaining meadows within their habitable bathymetric range in the project scenario that would have succumbed to bathymetric changes in the baseline scenario. Projects cannot claim credit for natural meadow recruitment or expansion in areas that become habitable due to bathymetric change expected in the baseline scenario.

5.10 Estimation of Area of Eroded Strata

Tidal wetlands may be subject to two forms of erosion: a) Seaward edges of wetlands are subject to migration due to changes in local sea level, regional sediment delivery, and impacts of human actions (e.g., nearby excavation of shipping channels);. b) In sheltered settings, away from open shores, wetlands may also erode internally through channel enlargement if sediment supply for wetland accretion is insufficient to keep pace with sea-level rise.

Projections of future erosion must take into account scaling of wetland retreat against projections of accelerated sea-level rise, any modification to sediment supply and human action.

Channel densities (surface area of channel per surface area of wetland) greater than 20% and/or changes in wetland vegetation consistent with increased duration or depth of flooding is an indication that the wetland may not be keeping pace with sea level. Similarly, a decline in surface elevation relative to a datum of mean high water surface spring elevation in the interior of the tidal wetland is an indication of wetland sensitivity to sediment supply under conditions of sea-level rise. Sites with an annual average suspended sediment load in flooding waters of >300 mg/l may be considered resilient to sea-level rise in terms of surface accretion. The project proponent should take into these indicators of wetland potential sensitivity to sea-level rise when considering whether to extend the eroded area strata to include marsh interior.

Because such projections are driven by conditions specific to individual project settings, expert knowledge from an experienced geomorphologist / coastal engineer must be utilized for complex projects.

5.11 Stratification of Vegetation Cover for Adoption of the default SOC Accumulation rate

The default factor for SOC accumulation rate (see Module *BL-TW*) may only be applied to non-seagrass tidal wetland systems with a crown cover of at least 50 percent. Areas below this threshold must be marked and excluded from the application of the default SOC accumulation rate. For the baseline scenario, crown covers must be based on a time series of vegetation composition. For the project scenario, crown cover mapping must be performed according to established methods in scientific literature.

5.12 Stratification of Salinity for the Accounting of CH_4

Tidal wetlands may be stratified according to salinity for the purpose of estimating CH_4 emissions. Threshold values of salinity for mapping salinity strata are specified in Module *BL-TW*.

Areas with unrestricted tidal exchange will maintain salinity levels similar to the tidal water source, while those with infrequent tidal flooding will not (in which case the use of channel water salinity levels is not reliable). For such areas it is therefore recommended to stratify according to the frequency of tidal exchange.

Procedures for the measurement of salinity levels are specified in Module *M-TW*.

5.13 Stratification of Water Bodies Lacking Tidal Exchange

The area of ponds, ditches or similar bodies of water within the project area must be measured and treated as separate strata when they do not have surface tidal water exchange. CH_4 emissions from these features may be excluded from GHG accounting if the area of these features does not increase in the project scenario.

6 DATA AND PARAMETERS

6.1 Data and Parameters Available at Validation

Data / Parameter	$A_{BSL,i}$ or A_i
Data unit	ha
Description	Area of baseline stratum *i*
Equations	1, ~~6~~9, ~~8~~11, 12, 17 or ~~7~~10
Source of data	Own assessment
Value applied	N/A
Justification of choice of data or description of measurement methods and procedures applied	Delineation of strata is preferably done using a Geographical Information System (GIS), which allows for integrating data from different sources (including GPS coordinates and remote sensing data). Applied techniques shall follow international standards of application or local standards as laid out in pertinent scientific literature or handbooks.~~GIS coverages, ground survey data and/or remote imagery (satellite or aerial photographs), as~~

	outlined in Chapter 5.
Purpose of Data	Calculation of baseline emissions
Comments	N/A

Data / Parameter	$Depth_{peat\text{-}BSL,i,t0}$ and $Depth_{peat\text{-}WPS,i,t0}$
Data unit	m
Description	Peat depth in the baseline scenario and the project scenario in stratum *i* at project start
Equations	2, 3, 4, 5
Source of data	Existing peat depth maps and/or field assessment and/or in combination with remote sensing data.
Value applied	N/A
Justification of choice of data or description of measurement methods and procedures applied	Procedures for monitoring peat depth are given in Module *M-PEAT* and in this module. Peat depths can be derived from • Existing peat depth maps • Literature datasets involving the project or similar areas. • Field measurements, eg, using a peat corer Remote sensing to derive height of the peat surface above datum.
Purpose of Data	Calculation of baseline emissions
Comments	In the absence of peer-reviewed data sources, the project proponent must justify that the data used are representative and that standard methods have been used.N/A

Data / Parameter	$Sub_{initial\text{-}BSL,\ i}$
Data unit	m yr^{-1}
Description	Subsidence in the initial years after drainage in stratum *i*
Equations	4
Source of data	Default factor from scientific literature or field assessments in peatland areas in the same region that underwent equal land use development as projected for the baseline scenario.
Value applied	N/A
Justification of choice of data or description of measurement methods and procedures applied	Deemed 0 for RDP projects. Procedures for measuring soil subsidence are described in Module *M-PEAT*
Purpose of Data	Calculation of baseline emissions
Comments	N/A

Data / Parameter	$Rate_{peatloss\text{-}BSL,i,t}$
Data unit	m yr^{-1}
Description	Rate of peat loss due to subsidence and fire in the baseline scenario in stratum *i* in year *t*
Equations	4, ~~9~~13
Source of data	Default factor from scientific literature or field assessments in peatland areas that are similar to the project area (proxy area)
Value applied	N/A
Justification of choice of data or description of measurement methods and procedures applied	See Section 5.4. Subsidence in the initial years after drainage is not included in this rate.
Purpose of Data	Calculation of baseline emissions
Comments	N/A

Data / Parameter	C_{vol_lower}
Data unit	kg C m^{-3}
Description	Volumetric carbon content of the peat below the water table in the baseline scenario
Equations	3, ~~9,~~ 10, 13
Source of data	Module *M-PEAT*
Value applied	N/A
Justification of choice of data or description of measurement methods and procedures applied	See Module *M-PEAT*
Purpose of Data	Calculation of baseline emissions Calculation of project emissions
Comments	N/A

Data / Parameter	$E_{peatsoil,CO2,i,t}$
Data unit	t CO_2e yr^{-1}
Description	CO_2 emissions from microbial decomposition of the peat soil in stratum *i* in year *t*
Equations	~~7~~10, 18~~11~~
Source of data	Module *BL-PEAT*
Value applied	N/A
Justification of choice of data or description of	See Module *BL-PEAT*

measurement methods and procedures applied	
Purpose of Data	Calculation of baseline emissions
Comments	N/A

Data / Parameter	$E_{peatburn,CO2,i,t}$
Data unit	t CO_2e yr^{-1}
Description	18
Equations	CO_2 emissions from burning of peat within the project boundary in the project scenario in stratum *i* in year *t*
Source of data	Module *BL-PEAT*
Value applied	N/A
Justification of choice of data or description of measurement methods and procedures applied	See Module *BL-PEAT*
Purpose of Data	Calculation of baseline emissions
Comments	N/A

Data / Parameter	$Depth_{soil,i,t0}$
Data unit	m
Description	Mineral soil depth in stratum *i* at the project start date
Equations	8
Source of data	Direct measurements and/or literature datasets involving the project area or similar areas
Value applied	N/A
Justification of choice of data or description of measurement methods and procedures applied	Mineral soil depths at the project start date may be derived from direct measurements within the project area or literature datasets involving the project area or similar areas
Purpose of Data	Calculation of baseline emissions Calculation of the maximum quantity of GHG emission reductions that may be claimed by the project
Comments	In the absence of peer-reviewed data sources, the project proponent must justify that the data used are representative and that standard methods have been used.

Data / Parameter	$Rate_{Closs\text{-}BSL,i,t}$
Data unit	t C ha^{-1} yr^{-1}

Description	Rate of organic carbon loss in mineral soil due to oxidation in the baseline scenario in stratum *i* in year *t*
Equations	6, 15
Source of data	May be estimated using published values (see Module *BL-TW*) or either historical data collected from the project site or chronosequence data collected at similar sites (see Module *BL-TW*). Alternatively, a conservative (low) value may be applied that remains constant over time.
Value applied	N/A
Justification of choice of data or description of measurement methods and procedures applied	Extrapolation of $Rate_{Closs\text{-}BSL,i}$ over the entire project crediting period must account for the possibility of a non-linear decrease of soil organic carbon over time, including the tendency of organic carbon concentrations to approach steady-state equilibrium (see Section 5.6)
Purpose of Data	Calculation of baseline emissions Calculation of the maximum quantity of GHG emission reductions that may be claimed by the project
Comments	In the absence of an accurate value for the determination of the SDT, a conservative (high) value may be applied, while for the determination of the maximum quantity of GHG emission reductions which may be claimed from the soil carbon pool, a conservative (low) value may be applied that remains constant over time. Reassessed when baseline is reassessed

Data / Parameter	$Rate_{Closs\text{-}WPS,i,t}$
Data unit	t C ha^{-1} yr^{-1}
Description	Rate of organic carbon loss in mineral soil due to oxidation in the project scenario in stratum *i* in year *t*
Equations	7, 16
Source of data	N/A
Value applied	0
Justification of choice of data or description of measurement methods and procedures applied	This value is conservatively set to zero, as loss rates are likely to be negative. The value must be reassessed when the baseline is reassessed. If at that event there is evidence that SOC has decreased, the calculation must be adjusted using the carbon loss rate to date, unless it can be shown that the carbon loss was temporary.
Purpose of Data	Calculation of project emissions Calculation of the maximum quantity of GHG emission reductions that may be claimed by the project

Comments	Reassessed when baseline is reassessed

Data / Parameter	$C_{BSL\text{-}aerobic,i,t}$
Data unit	t C ha^{-1} yr^{-1}
Description	C mass present in soil exposed to an aerobic environment in the baseline scenario in stratum *i* in year *t*
Equations	22
Source of data	
Value applied	N/A
Justification of choice of data or description of measurement methods and procedures applied	
Purpose of Data	Calculation of project emissions Calculation of the maximum quantity of GHG emission reductions that may be claimed by the project
Comments	

Data / Parameter	$C_{BSL\text{-}aerobic,i,t\text{-}steadystate}$
Data unit	t C ha^{-1} yr^{-1}
Description	Mass of C present in soil exposed to an aerobic environment in the baseline scenario in stratum *i* in year *t,* when the C mass has reached steady state equilibrium, in mineral soils
Equations	22
Source of data	
Value applied	
Justification of choice of data or description of measurement methods and procedures applied	
Purpose of Data	Calculation of project emissions Calculation of the maximum quantity of GHG emission reductions that may be claimed by the project
Comments	

Data / Parameter	$t_{steadystate}$
Data unit	yr
Description	The year in which the C mass has reached steady state equilibrium, in mineral soils

Equations	
Source of data	
Value applied	
Justification of choice of data or description of measurement methods and procedures applied	
Purpose of Data	Calculation of project emissions Calculation of the maximum quantity of GHG emission reductions that may be claimed by the project
Comments	

6.2 Data and Parameters Monitored

Data / Parameter:	$A_{WPS,i}$ or A_i
Data unit:	ha
Description:	Area of project stratum *i*
Equations	1, 69, 811, 12, 17 or 710
Source of data:	Own assessment
Description of measurement methods and procedures to be applied:	GIS coverages, ground survey data and/or remote imagery (satellite or aerial photographs), as outlined in Section 5.
Frequency of monitoring/recording:	At each monitoring event
QA/QC procedures to be applied:	See Section 9.3 of *REDD-+ MF* or other VCS methodology that uses this module.
Purpose of data:	Calculation of project emissions
Calculation method:	N/A
Comments:	N/A

Data / Parameter:	$Rate_{peatloss\text{-}WPS,i,t}$
Data unit:	m yr^{-1}
Description:	Rate of peat loss due to subsidence and fire in the project scenario in stratum *i* in year *t*
Equations	5, 1014
Source of data:	Module *M-PEAT*
Description of measurement methods	See Module *M-PEAT*

and procedures to be applied:	
Frequency of monitoring/recording:	See Module *M-PEAT*
QA/QC procedures to be applied:	See Module *M-PEAT*
Purpose of data:	Calculation of project emissions
Calculation method:	N/A
Comments:	N/A

Data / Parameter:	$E_{peatsoil,CO2,i,t}$
Data unit:	t CO_2-e yr^{-1}
Description:	CO_2 emissions from microbial decomposition of the peat soil in stratum *i* in year *t*
Equations	~~7~~10, ~~11~~18
Source of data:	Module *M-PEAT*
Description of measurement methods and procedures to be applied:	See Module *M-PEAT*
Frequency of monitoring/recording:	See Module *M-PEAT*
QA/QC procedures to be applied:	See Module *M-PEAT*
Purpose of data:	Calculation of project emissions
Calculation method:	N/A
Comments:	N/A

Data / Parameter:	$E_{peatburn,CO2,i,t}$
Data unit:	t CO_2e yr^{-1}
Description:	CO_2 emissions from burning of peat within the project boundary in the project scenario in stratum *i* in year *t*
Equations	~~7, 11~~18
Source of data:	Module *M-PEAT*
Description of measurement methods and procedures to be applied:	See Module *M-PEAT*
Frequency of monitoring/recording:	See Module *M-PEAT*

QA/QC procedures to be applied:	See Module *M-PEAT*
Purpose of data:	Calculation of project emissions
Calculation method:	N/A
Comments:	N/A

7 REFERENCES

Congalton, R.G. 1991. A review of *Assessing the Accuracy of Classifications of Remotely Sensed Data*. *Remote Sensing of Environment* 37: 35-46.

Congalton, R.G., Russell G., and Kass G. 2008. *Assessing the Accuracy of Remotely Sensed Data: Principles and Practices*. CRC press.

Couwenberg, J., Thiele, A., Tanneberger, F., Augustin, J., Bärisch, S., Dubovik, D., Liashchynskaya, N., Michaelis, D., Minke, M., Skuratovich, A. and Joosten, H. 2011. Assessing greenhouse gas emissions from peatlands using vegetation as a proxy. *Hydrobiologia* 674: 67-89.

French, J. 2006. Tidal marsh sedimentation and resilience to environmental change: Exploratory modelling of tidal, sea-level and sediment supply forcing in predominantly allochthonous systems. *Marine Geology* 235: 119-136.

IPCC. 2013. Supplement to the *2006 Guidelines for National Greenhouse Gas Inventories: Wetlands*.

Jaenicke, J., Rieley, J.O., Mott, C., Kimman, P., Siegert, F. 2008. Determination of the amount of carbon stored in Indonesian peatlands. *Geoderma* 147: 151-158

Morris, J.T., Edwards, J., Crooks, S., Reyes, E. 2012. Assessment of carbon sequestration potential in coastal wetlands. pp 517-532. In: *Recarbonization of the Bioshpere: Ecosystem and Global Carbon Cycle*. R. Lal, K. Lorenz, R. Hüttl, B. U. Schneider, J. von Braun (eds). Springer.

Orr, M.K., Crooks, S., and William, P.B. 2003. Issues in San Francisco Estuary tidal restoration: Will restored tidal marshes be sustainable? *San Francisco and Watershed Science* 1: 108-142. http://www.escholarship.org/uc/item/8hj3d20t

Stephens, J.C., Allen, L.H., Chen, E. 1984. Organic soil subsidence. In: *Man Induced Land Subsidence* (ed. T. L. Holzer), pp. 107–122. Geological Society of America, Boulder, CO.

Stralberg, D., Brennan, M., Callaway, J.C., Wood, J.K., Schile, L.M., Jongsomjit, D., Kelly, M., Parker, V.T., Crooks, S. 2011. Evaluating tidal marsh sustainability in the face of sea-level rise: A hybrid modeling approach applied to San Francisco Bay. *PlosONE*. http://www.plosone.org/article/info%3Adoi%2F10.1371%2Fjournal.pone.0027388.

DOCUMENT HISTORY

Version	Date	Comment
v1.0	3 Dec 2010	Initial version
v1.1	9 Mar 2015	The module was updated to include activities on peatlands.