



ACWIS Methodology

Australasian Catchment Water Improvement Standard (ACWIS) Method, accounting for fine sediment abatement through improved grazing land management.

V1.0

June 2026



Method Title

Australasian Catchment Water Improvement Standard (ACWIS) Method for accounting for fine sediment abatement through improved grazing land management.

Version

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Lead Authors¹

Ben Silverwood, Andrew Yates, Adam Costin, Olivier Decitre, Dr Bernhard Wehr

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Consultation Process

This Method is a variation of the Reef Credit GLM Method that was informed by discussions held at two workshops in March 2022 and February 2023.

Method Concept

This Methodology, referred to as the Method herein, describes the approach to achieve and quantify reductions in Fine Sediment (FS) from hillslope soil losses in rural landscapes through improved grazing land management. Sediment calculations under this Method are based on a hillslope soil loss model commonly applied, known as the Revised Universal Soil Loss Equation (RUSLE).

Application of this Method will generate Water Quality improvement credits that incentivise landholders to achieve FS abatement. Grazing land management improvements under this Method aim to achieve a higher level of ground cover before high intensity rainfall periods, reducing FS run-off and maximising the benefits to local waterways and end of catchments.

This Method minimises the effects of external influences such as seasonality by using an adaptation of Dynamic Reference Cover Modelling (DRCM), thus increasing the degree of confidence that observed changes in ground cover are attributable to the project activities rather than naturally occurring fluctuations and/or climate driven trends.

¹ Verterra Ecological Engineering

It is anticipated that some projects developed under this Method may occur in conjunction with other ecosystem service market opportunities (e.g. carbon farming on grazing lands), subject to satisfying the eligibility criteria of each scheme.

This Method establishes a nationally consistent framework for quantifying water quality improvement through grazing practice change. Where regionally specific circumstances or improved datasets are available, variations to the Method may be developed and applied, subject to appropriate technical justification and approval.

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Table of contents

1. PROJECT DESCRIPTION	5
1.1 GOVERNING DOCUMENTS.....	5
1.2 REFERENCES	5
1.3 SUMMARY DESCRIPTION OF METHODOLOGY	5
1.4 PROJECT ACTIVITIES	6
1.5 DEFINITIONS	6
1.6 DOCUMENTATION REQUIREMENTS.....	8
1.6.1 Project Application	8
1.6.2 Project Crediting.....	8
2. ELIGIBILITY.....	9
2.1 LOCATION	9
2.2 PROJECT LAND CHARACTERISTICS	9
2.3 PROJECT ACTIVITIES	9
2.3.1 Exclusions	10
2.4 LAND USE CHANGE.....	10
2.5 ADDITIONALITY	10
2.6 LEAKAGE	10
2.6.1 Determine if the project may be at risk of leakage	10
3. PROJECT MAPPING AND DATA REQUIREMENTS	12
3.1 GEOSPATIAL CAPTURE	12
3.2 FITNESS FOR PURPOSE	12
3.3 ACCURACY.....	12
3.4 DATA REQUIREMENTS	12
3.4.1 Rainfall measurement	13
3.4.2 Soil field sampling.....	13
4. GRAZING LAND MANAGEMENT PLAN.....	15
5. PROJECT ACCOUNTING	16
5.1 IDENTIFY DYNAMIC REFERENCE COVER PIXELS.....	16
5.2 DETERMINE SEASONAL PROJECT BASELINE GROUND COVER DIFFERENCE.....	18
5.3 DETERMINE MONITORING PERIOD ADJUSTED GROUND COVER	19
5.4 DETERMINE RUSLE FACTORS 'R', 'C', 'S', 'K'	21
5.5 BENEFIT ATTENUATION FACTOR.....	23
5.6 RELEVANT POOLS.....	25
5.7 ACCOUNTING FOR LEAKAGE.....	26
5.8 ACCOUNTING FOR DISTURBANCE	26
5.9 ACWIS CREDIT CALCULATION	26
5.10 UNCERTAINTY	27
6. MONITORING AND RECORD KEEPING REQUIREMENTS.....	27
7. REFERENCES	28

1. Project Description

1.1 Governing Documents

- Australasian Catchment Water Improvement Standard (ACWIS)
- Australasian Catchment Water Improvement Guide
- Australasian Catchment Water Improvement Definitions

1.2 References

This methodology references the following policy documents:

- National Water Quality Management Strategy (NWQMS)
- ACWIS Grazing Land Management Explanatory Statement
- Refer to Section 7 for all other references

1.3 Summary Description of Methodology

This methodology (here onwards called the ‘Method’) describes the approach to achieve and quantify reductions in Fine Sediment (FS) from hillslope soil losses from rural landscapes through improved grazing land management.

The core Method components include:

- **Determine eligibility:** Sets the criteria for eligibility of projects under the Method and ACWIS, including but not limited to additionality criteria.
- **Establish project boundaries and scope:** Provides the rules for defining the geographical and temporal boundaries of the project, scope of activities, and pollutant pools to be accounted for in the project.
- **Quantify FS proportion and K factor:** Describes the requirements for project soil sampling.
- **Establish rainfall monitoring:** Provides the requirements for rainfall monitoring to inform erosivity measurements.
- **Quantify baseline project ground cover difference:** Details how to calculate the baseline spatial ground cover difference from surrounding dynamic reference pixels.
- **Quantify baseline FS loss:** Details how to determine projected FS loss that would have occurred under the modelled baseline scenario by adjusting the satellite derived ground cover to match projected ground cover.
- **Quantify project FS loss:** Details how to determine project FS loss for the monitoring period using satellite derived ground cover.
- **Quantify FS reductions:** Details how to determine the reduction in FS resulting from project activities at end of catchment for the monitoring period.
- **Quantify ACWIS Credit units:** Outlines the steps to determine the number of ACWIS Credits based on calculated FS reductions.
- **Project Monitoring:** Provides the rules for the project monitoring and identifies parameters to assess compliance with the grazing land management strategy.

1.4 Project Activities

The scope of this Method includes the implementation of improved grazing land management to reduce the amount of FS loss from hillslopes. The Method allows for practice changes that are reasonably expected to increase ground cover. The Method is not limited to the activities described in Section 2.3, but the project must provide a Grazing Land Management Plan (GLM Plan) as part of the ACWIS Project Summary that describes the proposed activities for the project duration.

1.5 Definitions

- **Abatement:** The reduction in Fine Sediment delivered at the farm gate resulting from grazing interventions, calculated as the difference between baseline and project sediment loss.
- **ACWIS:** Australasian Catchment Water Improvement Standard.
- **Additionality:** As defined in the ACWIS Definitions, also Section 2.5.
- **ANCOLD:** Australian National Committee on Large Dams.
- **At-risk asset:** Has the meaning given in the ACWIS Standard. Determination of at-risk assets is undertaken in accordance with the ACWIS Standard and is not determined by this Methodology.
- **Australian Soil Classification (ASC):** A nationally recognised system for describing and categorising soils in Australia, (Isbell., 2021)
- **Baseline period:** 10 years from the Project Start Date.
- **Benefit Attenuation Factor:** The proportion of the benefit measured at the Project Area boundary that is reasonably expected to reach the at-risk asset of concern, after accounting for attenuation processes between the Project Area and the receiving environment or water infrastructure.
- **Broadscale clearing:** Removal of woody vegetation implemented at a paddock scale and resulting in the conversion of forest from >20% canopy cover to <20% canopy cover.
- **Business As Usual (BAU):** As defined by the ACWIS Definitions.
- **Credit Accounting Zone (CAZ):** Spatially explicit area delineated according to Section 3 of the Method in which project activities and project accounting occurs.
- **Catchment area:** The geographic area of land from which water, sediment, and nutrient flows to a common receiving point, within which the impacts of land management activities are assessed for crediting. For the purposes of ACWIS credits, a catchment defines the spatial boundary over which credits are calculated.
- **Crediting period:** As defined by the ACWIS Definitions. For this Method the period is 25 years.
- **Disturbance event:** Either a natural disturbance that would result in an immediate loss of ground cover such as unplanned fire activities, or any pre-planned event that would result in an immediate loss of ground cover such as planned fire activities, earth works, or broadscale clearing.
- **Dynamic Reference Cover Modelling (DRCM):** Is the process of continuously updating a set of reference points to accurately represent the evolving dynamics of a changing environment (Bastin et al., 2012).
- **DRCM buffer area:** A 10km zone around the Project Area boundary that accommodates variations in data or environmental changes, ensuring robust coverage and representation.

- **Fine Sediment (FS):** Soil particles comprising the clay and fine silt fractions, defined by a default particle size threshold of $< 63 \mu\text{m}$, unless a smaller particle size threshold is specified in an applicable Water Quality Improvement Plan (WQIP), regionally specific plan, or published in another authoritative source.
- **Grazing Land Management (GLM) Plan:** Documented proposal for implementing project activities for the duration of the project period. Requirements outlined in Section 4.
- **Ground cover:** Refers to the vegetation or materials that grow and spread across the ground surface, providing erosion control and habitat for various organisms.
- **Hillslope sediment delivery ratio (HSDR):** The proportion of sediment or pollutant mobilised on hillslopes within the Project Area that is expected to be delivered to the Project Area boundary via surface flow pathways. For the purposes of this Method, a default Ratio of 10% is applied.
- **Irrigation:** Is the artificial application of water to land and soil to assist in the growth of crops or vegetation.
- **Leakage:** As defined by the ACWIS Standard, also Section 2.6
- **Monitoring period:** As defined in the ACWIS Standard. For this Method, the minimum monitoring period is 12 months, and the maximum monitoring period is 5 years.
- **National Water Quality Management Strategy (NWQMS):** A nationally agreed, non-mandatory framework of policies, guidelines and tools to support consistent water quality management in Australia, developed collaboratively by Australian, State, and Territory Governments.
- **Project application:** As defined by the ACWIS Definitions.
- **Project area:** As defined by the ACWIS Definitions.
- **Project end date:** As defined by the ACWIS Definitions.
- **Project start date:** As defined by the ACWIS Definitions.
- **Reference areas:** Minimally disturbed areas used to benchmark changes in ground cover through time. These areas act as a synthetic control that is compared against project areas.
- **Revised Universal Soil Loss Equation (RUSLE):** A predictive model used to determine hillslope soil erosion rates by factoring in the effects of rainfall, soil type, slope, land cover, and conservation practices. The RUSLE does not estimate sediment deposition or gully erosion, (Renard et al., 1997; Wischmeier & Smith, 1978).
- **Regulated Minimum Ground Cover (RMGC):** The greater of either a stated regulatory minimum ground cover value at time of project registration, or the regulatory minimum ground cover at time of project reporting.
- **Storm:** Periods of rainfall separated by periods of no rainfall for more than 6 hours that exceeds either 12.7mm total, or with a maximum 12-minute rainfall of greater than 5.6mm, (Renard et al., 1997; Wischmeier & Smith, 1978; Yu, 1998).
- **Synthetic fertiliser application:** Refers to the process of applying synthetic nutrients to soil or plants to enhance their growth and productivity.
- **Time series step:** Seasonal (three months).
- **Woody vegetation:** Perennial plant that has primary supporting structures consisting of secondary xylem.
- **Wooded Foliage Projection Cover:** The measurement or estimation of the area covered by tree canopy or foliage in a wooded or forested area.

- **Water Quality Improvement Plan (WQIP):** A formally adopted, regionally specific planning document that defines water quality objectives, pollutant load reduction targets for a defined catchment or receiving environment. For the purposes of this Method, a WQIP may provide regionally approved definitions, parameter thresholds, default values, or target metrics that supersede default assumptions in this Method where explicitly referenced.

1.6 Documentation Requirements

1.6.1 Project Application

When applying for a ACWIS Credit project, the project documentation must include a Project Summary. The Summary must include:

- a. Names of project proponents and names of any individual or entity with interest in the land parcel or enterprise.
- b. Description of the project including:
 - i. Spatial files defining the Project Area
 - ii. Spatial files defining DRCM Buffer Area
 - iii. Spatial files defining CAZ
 - iv. Estimate of average baseline FS loss
 - v. Estimate of abatement potential over the crediting period.

The project application must also include the first version of the Grazing Land Management (GLM) Plan and a Project Eligibility Report outlining how the project complies with:

- a) ACWIS, including but not limited to legal right and consent; and
- b) The eligibility requirements specified in the Section 2 of the Method, including but not limited to the demonstration of additionality; and
- c) Any legislative requirements.

1.6.2 Project Crediting

When applying for issuance of ACWIS Credits, project documentation must include:

- Project Summary
- Project Eligibility Report
- Grazing Land Management Plan
- Spatial Report
- Project Abatement Report
- Project Monitoring Report
- Evidentiary Documents including spatial files as required by Section 6.

In addition to the requirements outlined in this Method, the project documentation must address how the project complies with ACWIS when applying this Method (e.g. documentary evidence of land ownership or rights to land management over the project area) and meets any legislative requirements.

Crediting applications must also be accompanied by a third-party verification report if required and prepared in accordance with ACWIS.

2. Eligibility

This section outlines the project eligibility criteria to implement this Method under ACWIS. For each of the eligibility criteria, credible evidence in the form of analysis, documentation, and/or third-party expert reports are required as part of the project application.

2.1 Location

The proposed project area must be located within Australia.

2.2 Project Land Characteristics

The Project Area must only include land where:

- Grazing is the principal land use for 10 years prior to Project Start; and
- Broad scale clearing of woody vegetation has not occurred within the previous 10 years^{*}; and
- Project activities are reasonably expected to improve ground cover beyond what is required by existing legislation and/or other pre-existing formalised obligations; and
- The project proponent has the legal right to manage implementation of project activities.

^{*}Land that has been broadly cleared of woody vegetation can be included in the CAZ for a crediting period if the following conditions are met:

- At least 15 years must have passed since the last clearing of the land; and
- The 5 years immediately following the clearing must not be part of the baseline scenario used for assessing that land.

This means that the land can be credited towards conservation goals after a 15-year period, provided the first 5 years after clearing are excluded from the baseline assessment.

2.3 Project Activities

Project activities as described in section 1.4 must:

- Include one or more grazing practice change activity that is reasonably expected to increase ground cover;
- Be consistent with relevant regional plans and strategies such as those outlined in the National Water Quality Management Strategy (NWQMS), or regional WQIP and NRM Plans, or otherwise provide justification as to why regional plans should be over-ridden;
- Be compliant with all Australian, State, Territory, and Local Government laws and regulations; and
- Demonstrate additionality.

Practice changes reasonably expected to increase ground cover may include:

- Matching stocking to forage budgets;
- Rotational grazing and wet season spelling, 'periods of rest';
- Infrastructure investment, i.e., fencing and water;
- Land remediation, i.e., pasture and native vegetation management, weed control, feral animal control; or
- Any other intervention undertaken to increase ground cover which are fully described by the project proponent in the GLM Plan.

2.3.1 Exclusions

The following activities are not eligible for ACWIS Credits under this Method:

- Irrigation, including pasture irrigation; or
- Broadscale clearing of woody vegetation; or
- Activities identified as excluded activities under the ACWIS Standard.

2.4 Land Use Change

If the project involves a change in land use to carry out an eligible project activity, the project proponent must have obtained all necessary permits and approvals (all levels of government as necessary).

Proponents must also outline in the GLM Plan the steps taken to ensure the project will not have a negative impact on catchment water quality.

2.5 Additionality

For a project to qualify as additional, it must initially fulfil the following requirements:

- The project proponent must demonstrate that the water quality improvements generated by the project are additional to the baseline condition and would not reasonably be expected to occur in the absence of the project.
- ACWIS Credits can only be generated from activities that are additional to that required by laws, regulations, and/or other formalised obligations; and
- Project activities must constitute in-scope (acceptable) project activities under the ACWIS Standard;
- Project activities must not comprise excluded activities under the ACWIS Standard; and

2.6 Leakage

Leakage may be considered to occur if there is a displacement of activities that increase FS erosion relative to BAU on areas within the catchment and outside of the project CAZ due to the implementation of the project.

For example: By reducing grazing pressure within the project CAZ there might be a consequential increase in grazing pressure, that results in beyond BAU erosion, on areas outside the CAZ.

This includes:

- **Scenario 1:** Land beyond the Project Area (including other properties) within operational control of the project participant/s of the same agricultural enterprise, i.e., grazing.
- **Scenario 2:** Land within the Project Area but not within the CAZ, i.e., land not monitored by satellite ground cover mapping due to having > 60% woody vegetation.

Project proponents must complete the steps under 2.6.1 at the time of the project application and each monitoring period to determine if there is a risk of project leakage and if so, implement the appropriate procedure to account for leakage.

2.6.1 Determine if the project may be at risk of leakage

The risk is an increase in FS erosion in areas outside the CAZ to maximize the ACWIS Credit benefit within the CAZ. The following applies to manage this risk under each leakage scenario:

Scenario 1 - Land beyond the Project Area:

- **Step 1:** Identify if the landowner or land manager is responsible for managing other agricultural land within the benefit catchment area, outside the Project Area. If the answer is ‘no,’ the risk of project leakage is considered zero and the project proponent can proceed to Section 3. If the answer is ‘yes,’ this land is at risk of leakage. The project proponent must follow the procedures for mapping land at risk of leakage as described in Section 3 - Project Mapping and then move to Step 2.
- **Step 2:** Once the area of land at risk has been identified, assess the credible risk that the project might increase BAU FS erosion on this land. Include a description of BAU activities that could lead to FS erosion and evaluate how the project might shift these activities in a way that could materially increase erosion. This assessment should be documented in the GLM Plan. If the assessment finds no plausible risk of increased erosion due to the project (e.g., due to existing land management practices), then the risk of project leakage is considered unlikely, and the proponent should proceed to Section 3. If the assessment finds a plausible risk of increased erosion due to the project, then the risk of project leakage is considered likely, proceed to Step 3.
- **Step 3:** If the risk of project leakage is considered likely, the proponent must include a leakage risk mitigation strategy in the GLM Plan. This strategy should detail the steps that will be taken to prevent leakage. Compliance with this strategy must be monitored and reported at the end of each monitoring period. If compliance is demonstrated, the residual risk of leakage is considered unlikely. If compliance cannot be demonstrated, the residual risk is likely, proceed to Step 4.
- **Step 4:** The project proponent must determine the best method to conservatively quantify FS loss due to leakage. This involves calculating the change from BAU activities and making a leakage deduction from the final ACWIS Credit volume, as outlined in Section 5, Equation 15.

Scenario 2 - Land within the Project Area but not within the CAZ:

- **Step 1:** Check if the Project Area and the CAZ are the same for the monitoring period. If they are the same the risk of project leakage is considered zero. If they are not the same, proceed to Step 2.
- **Step 2:** For land within the Project Area but outside the CAZ, if FS loss can be calculated as described in Section 5, any increase in FS loss within this area compared to the expected baseline must be subtracted from the total abatement for the monitoring period, according to Section 5 Equation 15. If FS loss cannot be calculated for this land as described in Section 5 Equation 15, proceed to Step 3.
- **Step 3:** For land within the Project Area but outside the CAZ, where FS loss cannot be calculated (e.g., wooded areas not covered by ground cover imagery), the proponent must include a leakage risk mitigation strategy in the GLM Plan. This strategy should outline the steps to prevent leakage. Compliance with this strategy must be monitored and reported at the end of each monitoring period. If compliance is demonstrated, the residual risk of leakage is considered unlikely, and the proponent should proceed to Section 3. If compliance cannot be demonstrated, the residual risk of leakage is considered likely, and you should proceed to Step 4.
- **Step 4:** The project proponent must determine the most conservative method to quantify FS loss due to leakage. This involves calculating the change from BAU activities and making a leakage deduction from the final ACWIS Credit volume, as specified in Section 5, Equation 15.

3. Project Mapping and Data Requirements

The boundaries of the Project Area, CAZ, and all other mapping required for reporting must be delineated in accordance with the requirements of this section.

3.1 Geospatial capture

A project proponent may use any of the following sources of data to delineate the boundaries of, and features within the Project Area and CAZ:

- Derived photogrammetry
- Air-photo photogrammetry
- LiDAR
- Ortho-rectified aerial photographs
- Ortho-rectified satellite imagery
- Cadastral database

3.2 Fitness for purpose

Prior to using a dataset, project proponents should assess the appropriateness of the dataset for the intended use, or its fitness for purpose against criteria that include:

- Age
- Scale
- Resolution
- Accuracy
- Classification, aggregation, generalisation systems (for example, smoothing)
- Integrity of dataset

3.3 Accuracy

The minimum requirement for spatial data is a horizontal accuracy of at least 10 metres at 95 percent threshold. Evidence of this data accuracy must be included in the Spatial Report. For the RUSLE calculations, the accuracy of the specified data, as supplied, is considered acceptable. Detail provided in section 3.4.

3.4 Data Requirements

Table 1 details data type, quality, and source for each RUSLE factor and source data.

Table 1: Data Requirements

RUSLE - Factor requirement	Data Type	Data Quality	Data Source (Below)
R - Rainfall	Raster	Derived from rainfall gauge data	(a)
K – Soil erodibility	Raster	Derived from soil sampling	(b)
L – Slope length	Raster / Constant	Constant = 1	(c)
S – Slope	Raster	Derived from SRTM DEM product - ~30m grid cell	(d)
P – Conservation (Practice factor)	Raster / Constant	Constant = 1	(c)

C – Cover management	Raster	From unaltered supplied source data.	(e)
Source Data	Data Type	Data Quality	Data Source (Below)
Ground cover	Raster	From unaltered supplied source data.	(f)
Hillslope Sediment Delivery Ratio (HSDR)	Constant	Constant = 0.1	(g)
Fine Sediment Proportion (FS)	Raster	Derived from soil sampling	(h)
Regulated minimum ground cover (RMGC)	Constant	Constant – In catchments where legislation requires a regulated minimum cover	(i)

- a) Derived using equation 11 with data from rainfall gauge, see Section 3.4.1
- b) Derived from results of the soil sampling, see Section 3.4.2
- c) All areas given default factor of 1
- d) SRTM DEM product derived, with slope in % and Equation 14
- e) Derived using Equations 12 and 13 using ground cover
- f) Derived from equation 1 with ground cover data sourced from *tern*, with a minimum seasonal capture, 30m/pixel, and restricted to < 60% woody vegetation
(At time of publication: TERN: Seasonal Ground Cover - Landsat, JRSRP Algorithm Version 3.0, Australia Coverage)
- g) Default factor of 0.1
- h) Derived from results of the soil sampling, see Section 3.4.2
- i) Catchment or receptor specific, sourced as appropriate

Data layers without temporal variability are fixed as the most recent layers at the time of project registration. Proponents can elect to incorporate all subsequent updated layers at each report but must continue with all updated layers for subsequent reports.

3.4.1 Rainfall measurement

A rainfall intensity measurement is to be conducted within the project area using a calibrated tipping bucket rain gauge that can report in 6-minute increments (minimum) and capture the expected range of rainfall rates.

Flow rate accuracy is to be at least +/-5% under 200mm/hr with yearly verification of operation within the specified accuracy limit to be documented.

3.4.2 Soil field sampling

3.4.2.1 Soil sampling plan

Prior to the commencement of the project, proponents are required to develop a Soil Sampling Plan as part of the GLM Plan for gathering required data to spatialise the FS proportion within the CAZ and determine required parameters for calculating K factors (equations 16, 17, 18). The following must be included within the Soil Sampling Plan:

- Soil stratification to inform sampling locations

- Determine profile permeability to inform K
- Determine surface structure to inform K
- Undertake laboratory analysis to determine FS proportion and inform K

Soil Stratification

The minimum number of strata required for a Soil Sampling Plan (both FS and K) is the total number of unique values of Soil Australian Soil Classification (ASC) raster that intersect with the CAZ. Surface (0-10cm) soil collection points within identified strata will, at minimum, be the greater of 3 samples per strata or 1 sample per 200ha of strata. Sampling locations are to be representative of each stratum, i.e., avoiding non-representative areas such as those recently disturbed, animal camps, erosion scars, or waterways for example.

Samples are to be bulked by strata and sent to a National Association of Testing Authorities (NATA) or Australasian Soil and Plant Analysis Council (ASPAC) accredited laboratory, for analysis. A complete chain of custody is required to allow the laboratory to match the sample to the appropriate analysis suite.

Profile permeability

At each sampling location, select a permeability class by estimating the soil profile's infiltration rate based on field indicators of soil structure, texture, and behaviour. Take the median of these classes to determine a single permeability value per strata.

Table 2 provides the method for estimating profile permeability, adapted from the National Committee on Soil and Terrain's Australian Soil and Land Survey Field Handbook (2024).

Table 2: Profile permeability classes

K factor class	Infiltration rate (mm/h)	Field indicators ^[1]
Class 1 (Rapid)	>130	Large continuous pores; very high connectivity; coarse sands, gravels, fractured rock
Class 2 (Moderate-Rapid)	60–130	Large continuous pores; macropore flow; apedal sands or strong polyhedral structure; sands, Ferrosols
Class 3 (Moderate)	20–60	Moderate to strong blocky / polyhedral structure; large continuous pores; red Kandosols, Ferrosols, sandy soils
Class 4 (Slow-Moderate)	5–20	Variable texture; moderate structure; pores / channels visible and open when wet; some Chromosols, Dermosols, Kandosols
Class 5 (Slow)	1–5	Clay / silty clay; few interconnected pores (hand lens); massive to strong structure; Vertosols, vertic clays
Class 6 (Very Slow)	<1	Clay / silty clay; no visible interconnected pores; structure closes on wetting; grey sodic clays, cemented pans

^[1] Field indicators were adapted from the *Australian Soil and Land Survey Field Handbook, 2024*

Surface soil structure

At each sampling location, assess the structure of the surface soil (0-100 mm) by taking a handful of air-dry soil, then gently crumble, observe, and record the natural aggregate size:

- Class 1 (very fine granular):

- Aggregates <1 mm
- Class 2 (fine granular):
 - Aggregates 1-2 mm
- Class 3 (medium to coarse granular):
 - Aggregates 2-10 mm
- Class 4 (blocky, platy, or massive):
 - Non-granular or weakly aggregated structures

Take the median of these classes to determine a single value per strata.

Laboratory analysis

Soil samples shall be tested for the analysis suite in Table 3.

Table 3: Laboratory analysis suite

Suite / analyte	Parameter	Reference Method ^[1]
Physico-chemical	Standard Particle Size Analysis	Hydrometer and/or Sieving (With chemical dispersant)
	Non-Dispersed Particle Size Analysis	Hydrometer and/or Sieving (No chemical dispersant)
Carbon	Organic Carbon	RL Method 6A1 (Walkley-Black)

^[1] 'RL Method' reference: Rayment and Lyons, 2011.

4. Grazing Land Management Plan

A Grazing Land Management (GLM) Plan for the Project Area must be prepared outlining the grazing strategies that are expected to increase ground cover. The GLM Plan must contain:

- Description of the grazing enterprise, including all properties in relevant catchments area under management, or subject to management arrangements (e.g. agistment or other stock relocation activities).
- Description of the baseline period GLM activities undertaken on the Project Area.
- Any descriptions, assessments, strategies required to comply with Section 2.6 Leakage.
- Soil Sampling Plan, Section 3.4.2.
- Maps and spatial files that delineate:
 - Project Area
 - ACWIS Credit Accounting Zones
 - Land subject to risk of leakage
 - Paddock location and size
 - Ground cover trends across the Project Area
 - Exclusion areas
 - Soil stratification that complies with Section 3.4.2
 - Proposed and actual soil sampling locations
 - Proposed and actual rainfall monitoring location/s
 - Anticipated and actual disturbance event boundary/ies
- Description of proposed GLM activities for each monitoring period, such as:

- Approach to measure and monitor pasture biomass and undertake forage budgets
- Approach to manage and monitor stock numbers
- Approach to manage leakage risk
- Approach to manage and monitor planned and unplanned disturbance events

The GLM Plan must be kept for the duration of the crediting period and be reviewed, updated, and submitted at the end of each monitoring period with the application for ACWIS Credits.

5. Project Accounting

ACWIS Credits are generated by calculating the difference in FS run-off between:

1. RUSLE from remotely monitored data; and
2. Modelled RUSLE from remotely monitored data adjusted using cover data from the baseline period.

Broadly, the project accounting steps require the following:

1. Identify baseline dynamic reference cover pixels
2. Determine seasonal project baseline difference (including accounting for regulated minimums)
3. Identify project dynamic reference cover pixels
4. Determine monitoring period and adjusted ground cover
5. Determine RUSLE factors 'R', 'C', 'K', 'S' and modelled 'C'
6. Undertake sediment abatement calculations
7. Apply relevant pools
8. Account for leakage
9. Account for disturbance events
10. Calculate Credit

5.1 Identify Dynamic Reference Cover Pixels

Dynamic Reference Cover Modelling (DRCM) is used to adjust ground cover changes for seasonal influences. In this Method, minimally disturbed areas termed 'reference areas' are used to benchmark changes in ground cover through time. These areas can be thought of as a synthetic 'control' that are compared against areas where project activities have been implemented. This Method assumes that within reference areas, changes in ground cover result primarily from the influence of weather and climate conditions rather than grazing land management or other disturbances. Calculating the difference in ground cover between the reference and CAZ areas is therefore a measure of grazing impact on ground cover.

DRCM is specifically used in this Method to determine the average seasonal difference in ground cover between the reference and CAZ areas. This calculation is undertaken for the baseline period (10 years prior to project registration) and in each Monitoring period (10 years prior to project registration to Monitoring Period end date). The average calculated in the Baseline is used to adjust the measured seasonal cover in the Monitoring Period so the influence of weather and climate on ground cover can be removed and change attributed to project activities determined.

To identify the reference areas for the baseline period:

- Download ground cover data from 10 years prior to project registration date that includes the extent of the Project Area and the 10km DRCM buffer area.

- Identify the pixel-wise lowest ground cover percentage using all data. Create a minimum baseline period layer from this data (that is, the lowest average seasonal ground cover within the baseline period for each pixel).
- Select all pixels within the highest 90-95 percentile range (Bastin et al., 2012) within the minimum baseline period layer.
- These are the baseline period reference area pixels that when averaged are used to determine the baseline period ground cover for each season, all other measured pixels within the CAZ area are referred to as project area pixels.

To identify the reference area cover pixels for each season of the monitoring period:

- Download ground cover data from 10 years prior to registration to the monitoring period end date that includes the extent of the Project Area and the 10km DRCM buffer area.
- Identify the pixel-wise lowest ground cover percentage for all data. Create a minimum layer from this data (that is the lowest average seasonal ground cover from the period back to 10 years from the project registration date for each pixel).
- Select all pixels within the highest 90-95 percentile range (Bastin et al., 2012) within the minimum layer.
- These are the monitoring period reference area pixels that when averaged are used to determine the ground cover reference for each season, all other measured pixels within the CAZ area are referred to as project area pixels.

The following equations are used to identify the dynamic reference pixels.

Note: Equations denote raw seasonal data that spans across multiple years as i (e.g., Summer 2016, Summer 2017, ...) and calendar seasonal data (Summer) that has been averaged as j .

Equation 1 – Seasonal ground cover proportion (GC_i)

For the season i the ground cover proportion (0 – 1) is derived from seasonal blended ground cover as defined in Section 3.4 and converted to equivalent visual ground cover (Trevithick et. al 2013):

$$GC_i = 0.925 \times \left(1 - \frac{(BG\%_i)}{100}\right)^2$$

Where:

GC_i = Ground cover proportion for raw data season i .

$BG\%_i$ = Bare ground percent for raw data season i from Tern

Equation 2 – Minimum ground cover (GC_{min})

Project area spatial minimum ground cover raster for all seasons (baseline or baseline and monitoring period):

$$GC_{min} = \text{minimum}(GC_k, GC_l, GC_m \dots)$$

Where:

GC_{min} = Spatial minimum ground cover of all raw seasonal data (either baseline or baseline and monitoring period).

GC_x = Ground cover for all raw data seasons ($k, l, m...$) within baseline (10 years prior to project registration) or within baseline and monitoring period (10 years prior to project registration to monitoring period end) – 10km DRCM buffer area extent.

Equation 3 – Reference cover pixel selection (GC^{ref})

Selection of dynamic reference cover pixels as a subset of the minimum cover raster layer:

$$GC^{ref} \subset GC_{min} \text{ (where } 90^{th} \text{ percentile} \leq GC_{min} \leq 95^{th} \text{ percentile)}$$

Where:

GC^{ref} = Reference pixels as a subset of the captured minimum ground cover raster (spatial wise pixels to be reference pixels under seasonal variation with least influence from management activities).

GC_{min} = Spatial minimum ground cover of all raw seasonal data (either baseline or baseline and monitoring period).

Equation 4 – Project area pixel selection ($GC^{project}$)

CAZ with reference pixels removed:

$$GC^{project} \subset CAZ \text{ (} GC^{ref} \text{ removed)}$$

Where:

$GC^{project}$ = Area within the project that has been defined as project measurement areas.

CAZ = Credit Accounting Zone.

GC^{ref} = Spatial area within the 10km buffer area that has been defined as dynamic reference pixels.

5.2 Determine Seasonal Project Baseline Ground Cover Difference

(Baseline scenario)

The baseline is the difference in average ground cover between the reference and project pixels, starting from 10 years prior to project registration. A baseline ground cover is required for each calendar season j .

The following equation is used to identify the calendar seasonal baseline ground cover.

Equation 5 – Seasonal difference between average reference ground cover and individual project area pixels accounting for regulated minimum ground cover (GC_i^{diff})

Raw data seasonal difference in ground cover between the average of the reference area and project area individual pixel ground cover:

$$GC_i^{diff} = \begin{cases} \text{mean}(GC^{ref}[GC_i]) - GC^{project}[GC_i], & GC^{project}[GC_i] \geq RMGC \\ \text{mean}(GC^{ref}[GC_i]) - RMGC, & GC^{project}[GC_i] < RMGC \end{cases}$$

Where:

GC_i^{diff} = Difference in cover between the mean reference cover pixels and the individual project pixels for the raw data season i .

$mean(GC^{ref}[GC_i])$ = The average ground cover of all reference pixels for the raw data season i .

$GC^{project}[GC_i]$ = The individual pixel ground cover value for the project pixels during the raw data season i .

$RMGC$ = The regulated minimum ground cover proportion.

Equation 6 – Baseline average calendar seasonal difference between reference ground cover and project area pixels (GC_j^{diff})

Baseline average calendar seasonal difference in ground cover between the reference area and project area individual pixel ground cover:

$$GC_j^{diff} = mean(GC_i^{diff})$$

Where:

GC_j^{diff} = Average difference in ground cover between the mean reference ground cover pixels and the individual project pixels for the calendar season j . (Example: Summer average baseline ground cover difference).

GC_i^{diff} = Difference in ground cover between the mean reference ground cover pixels and the individual project pixels for the raw data season i over the calendar season j . (Example: Summer 2017, Summer 2018, Summer 2019....).

5.3 Determine monitoring period adjusted ground cover

(Project reporting period calculations)

Identify reference and project pixels in accordance with the approach described by Sections 5.1 and 5.2 for the baseline from 10 years prior to project registration to the monitoring period end date. Note that the reference ground cover pixels might be different from the baseline due to altered grazing practices, or external impacts in the DRCM buffer area. Calculate the difference in average ground cover between the monitoring period reference pixel average and individual project pixels. This is required for each season.

For reporting, download required ground cover layers and identify reference and project pixels using the same approach as baselining (from 10 years prior to project registration to project reporting date). Noting the reference ground cover pixels might be different from the baseline due to altered grazing practices or external impacts in the DRCM buffer area. Calculate the difference in average ground cover between the project reporting reference pixel average and individual project pixels. This is required for each season.

For each of the project area pixels, adjust the seasonal monitoring period ground cover layer for the project area pixels to match the projected seasonal difference from the baseline. This is the BAU scenario that will be used to calculate change in FS run-off. This adjustment accounts for extended periods of wet or dry weather.

The following equations are used to calculate the difference in ground cover.

Equation 7 – Difference in ground cover between project and reference ground cover pixels (\widehat{GC}_i^{diff})

Calculating the difference for the monitoring period:

$$\widehat{GC}_i^{diff} = \text{mean}(GC^{ref}[GC_i]) - GC^{project}[GC_i]$$

Where:

\widehat{GC}_i^{diff} = Difference between measured ground cover for season i in project monitoring period for reference ground cover pixels and project area pixels.

$\text{mean}(GC^{ref}[GC_i])$ = The average ground cover of all reference pixels for the raw data season i .

$GC^{project}[GC_i]$ = The individual pixel ground cover value for the project pixels during the raw data season i .

Equation 8 – Difference from the difference projected by the baseline, of the difference between the project area and the reference area ground cover (difference of differences) ($\Delta\widehat{GC}_i^{diff}$)

Calculating the difference of the ground cover difference from the baseline projected for the monitoring period:

$$\Delta\widehat{GC}_i^{diff} = \widehat{GC}_i^{diff} - GC_j^{diff}$$

Where:

$\Delta\widehat{GC}_i^{diff}$ = Monitoring period project area ground cover difference from reference pixels difference from projected baseline levels for raw data season i – Correction factor for measured actual project ground cover to projected ground cover from baseline monitoring period – Difference from the projected difference for each pixel in the project area.

GC_j^{diff} = Pixel wise baseline projected ground cover difference of average reference pixels and project area pixels during calendar season j .

\widehat{GC}_i^{diff} = Pixel wise actual measured ground cover difference of average of the reference pixels and project area pixels during monitoring period raw data season i .

Equation 9 – Adjusted seasonal ground cover – Projected from baseline ground cover difference (GCA_i)

Measured seasonal ground cover adjusted to respect the difference projected from the baseline ground cover calculations:

$$GCA_i = GC_i + \Delta\widehat{GC}_i^{diff}$$

Where:

GCA_i = Adjusted ground cover proportion in raw data season i .

GC_i = Ground cover proportion in raw data season i .

$\Delta\widehat{GC}_i^{diff}$ = Monitoring period project area ground cover difference from reference pixels delta from projected baseline levels – Correction factor for measured actual project ground cover to projected ground cover from baseline monitoring period.

5.4 Determine RUSLE Factors ‘R’, ‘C’, ‘S’, ‘K’

(Project monitoring period calculations)

For the project monitoring period adjusted ground cover data, determine the ‘R’, ‘C’, ‘S’, and ‘K’ factors required for RUSLE calculation.

RUSLE

- R - factor from pluviograph rainfall data
- C - factor from ground cover
- S – factor from elevation data
- K – factor from soil sample data

Noting that all other RUSLE data modules are downloaded directly from relevant websites and are freely available for public use.

The following equations are used to calculate seasonal erosivity ‘R’, ground cover factors ‘C’, slope factor ‘S’, and soil factor ‘K’:

Equation 10 – Storm Rainfall Erosivity (E_l)

Using minimum 6-minute interval pluviograph data from the site monitoring station calculate storm (Section 1.5) rainfall erosivity, (Brown & Foster, 1987):

$$E_l = \sum_{k=1}^n 0.29[1 - 0.72e^{-0.05I_k}]\Delta t$$

Where:

E_l = Erosivity for storm l (MJ/ha).

n = number of time intervals of the storm.

I_k = Rainfall intensity for time interval k (mm/h).

Δt = Time interval (h).

Equation 11 – Seasonal Rainfall Erosivity (R^i)

For season i , the rainfall erosivity:

$$R^i = \sum_{l=1}^n E_l I_{30}^l$$

Where:

R^i = Erosivity for season i .

n = Number of storms in season i .

E_l = Rainfall intensity for storm l .

I_{30}^l = Maximum 30-minute intensity for storm l .

Equation 12 – Seasonal C Factor (C_i)

RUSLE cover and management factor in season i (Rosewell, 1997):

$$C_i = e^{-0.799 - (4.74 \times 10^{-2} * (GC_i * 100)) + (4.49 \times 10^{-4} * (GC_i * 100)^2) - (5.2 \times 10^{-6} * (GC_i * 100)^3)}$$

Where:

C_i = RUSLE cover and management factor in raw data season i .

GC_i = Ground cover proportion in raw data season i .

Equation 13 – Baseline C factor using measured ground cover and baseline adjusted ground cover (\dot{C}_i)

Creating a C factor adjusted for baseline expected difference in season i :

$$\dot{C}_i = \begin{cases} e^{-0.799 - (4.74 \times 10^{-2} * (GCA_i * 100)) + (4.49 \times 10^{-4} * (GCA_i * 100)^2) - (5.2 \times 10^{-6} * (GCA_i * 100)^3)}, & GCA_i \geq RMGC \\ e^{-0.799 - (4.74 \times 10^{-2} * (RMGC * 100)) + (4.49 \times 10^{-4} * (RMGC * 100)^2) - (5.2 \times 10^{-6} * (RMGC * 100)^3)}, & GCA_i < RMGC \end{cases}$$

Where:

\dot{C}_i = Modelled C factor for raw data season i .

GCA_i = Adjusted ground cover proportion for raw data season i .

$RMGC$ = The regulated minimum ground cover proportion

Equation 14 – Slope steepness - S Factor (S)

S Factor from land surface slope (Pangos et al., 2015):

$$S = \begin{cases} 10.8 * \sin\theta + 0.03, & \text{Slope} < 9\% \\ 16.8 * \sin\theta - 0.5, & 9\% \leq \text{Slope} < 50\% \\ 7.0145, & \text{Slope} \geq 50\% \end{cases}$$

Where:

S = Slope steepness factor

θ = Slope in degrees – SRTM ~30m/1 second maximum grid size.

Equation 15 – Percent passing 0.125 mm (P_{125})

Interpolate non-dispersed particle size analysis to estimate P_{125} (Loch et al., 1998):

$$P_{125} = a \times \ln(0.125) + b$$

Where:

P_{125} = percentage of particles <0.125 mm (%)

a = slope coefficient from plotted line equation

b = intercept coefficient from plotted line equation

Equation 16 – Organic matter content (*OM*)

Convert organic carbon to organic matter (Hazelton and Murphy, 2016):

$$OM = OC \times 1.72$$

Where:

OM = organic matter content (%)

OC = organic carbon content (%)

Equation 17 – Wet sediment density (*ds*)

Wet sediment density from non-dispersed particle size analysis (Loch et al., 1998):

$$ds = 1.462 + 0.048(1.03259^{sand\%})$$

Where:

ds = density of wet sediment (tonne/m³)

sand% = percentage of fine (0.02-0.2 mm) + coarse (0.2-2.0 mm) sand content (%)

Equation 18 – Soil erodibility - K Factor (*K*)

The following equation calculates the RUSLE soil erodibility (*K*) factor based on Loch and Rosewell (1992), which modifies the original nomograph equation (Wischmeier et al. 1971) by substituting 100(*P*₁₂₅) as a surrogate for the *M* parameter and incorporating wet sediment density (*ds*) to better predict the erodibility of all soil types (including heavy clays).

$$K = \frac{2.77 \times (100P_{125})^{1.14} \times 10^{-7} \times (12 - OM) + 4.28 \times 10^{-3} \times (SS - 2) + 3.29 \times 10^{-3} \times (PP - 3)}{(ds - 1)}$$

Where:

K = soil erodibility factor (t h/MJ mm)

*P*₁₂₅ = percentage of particles <0.125 mm (%)

OM = organic matter content (%)

SS = soil structure class (1-4)

PP = soil permeability class (1-6)

ds = wet sediment density (Mg/m³)

5.5 Benefit attenuation factor

(Determine Benefit attenuation factor)

The Benefit Attenuation Factor (BAF) represents the proportion of the environmental benefit generated within the Project Area that can be expected to reach the at-risk asset of concern. This Method provides a hierarchy of approaches for determining the BAF, reflecting the availability of catchment-specific information:

- **Option 1:** Where a measure of benefit attenuation is established in the water quality management arrangements (WQIP, Catchment Strategy, or similar) for that catchment setting, that measure must be applied as the BAF.
- **Option 2:** Where Option 1 is not available, a measure of benefit attenuation must be derived. Users can select between:
 - **Option 2a:** In the absence of such an established measure (Option 1), a measure of benefit attenuation based on the best available data and interpretation relevant to the defined catchment setting using the benefit attenuation calculation provided in the Method must be applied as the Benefit Attenuation Factor, or;
 - **Option 2b:** The ACWIS Default Benefit Attenuation Factor (below) may be applied. This is the most conservative percentage of the benefit calculated at the project area boundary ('farm gate') that can be recognised as reaching the asset of concern and is therefore available for crediting (Creditable Benefit Units).

ACWIS Default Benefit Attenuation Factor

Where the ACWIS Default Benefit Attenuation Factor is applied (Option 2b), the following cases are used depending on the separation between the Project Area boundary and the at-risk asset of concern, and the presence of in-line retention infrastructure:

- **CASE A – No Separation:**
There is no separation between the Project Area boundary and the at-risk asset of concern.
Default Factor: 100%
- **CASE B – Phased Separation without infrastructure:**
There is a separation between the Project Area boundary and the at-risk asset of concern, but no in-line retention infrastructure is present as listed on the ANCOLD (Australian National Committee on Large Dams). Default Factor by separation distance:

Equation 19: Phased separation without infrastructure (*BAF*)

$$BAF = \begin{cases} 100\%, & Dist < 50km \\ -0.2 \times Dist + 110, & 50km \leq Dist < 500km \\ 0\%, & Dist \geq 500km \end{cases}$$

- **CASE C – Phased Separation with infrastructure:**
There is a separation not exceeding 500 km between the Project Area boundary and the at-risk asset of concern, and in-line retention infrastructure is present as listed on the ANCOLD.
Default Factor: Calculated as the percentage of load reduction at the Project Area Boundary represented by the fine fraction of the residual wash load in the downstream outflow of the infrastructure closest to the Project Area boundary. This is determined using the Brune curve equation for reservoir deposition (Equation 20):

Equation 20: Reservoir trap efficiency (*TE*)

$$TE = \frac{119.6 \frac{C}{I}}{0.012 + 1.02 \frac{C}{I}} - 22$$

Where:

TE = Reservoir trap efficiency in %

$\frac{C}{I}$ = Ratio of reservoir storage capacity to mean annual input discharge

The ANCOLD listing provides reservoir storage capacities. Mean annual input discharge can be calculated from upstream river gauges.

5.6 Relevant pools

(Calculation of change in pollutant to at risk asset)

The relevant pollutant pool is the FS delivered to the at-risk asset of concern. The reduction achieved during the monitoring period in FS exports transported to the end of catchment, must be calculated by applying the following equation that uses spatial RUSLE and applies spatial FS proportion and delivery ratio data.

Equation 21 – Calculation of modelled delivery difference – Actual vs. Modelled from baseline projected ground cover ($FSAr$)

$$FSAr = \left(\sum_{i=1}^n R^i K L S \dot{C}_i P FS HSDR BAF CS \right) - \left(\sum_{i=1}^n R^i K L S P C_i FS HSDR BAF CS \right)$$

Where:

$FSAr$ = Abatement of FS, in tonnes, to the at-risk asset of concern for monitoring period, r , over the CAZ.

n = Seasons in monitoring period.

i = Season.

R^i = Rainfall erosivity at season i .

K = Soil erodibility – raster (Refer to Table 1).

L = Slope length – constant raster (Refer to Table 1).

S = Slope steepness – raster (Refer to Table 1).

C_i = Cover management factor, from measured satellite ground cover in season i .

\dot{C}_i = Modelled cover management factor, created from measured satellite ground cover in raw data season i adjusted with baseline cover adjustment factor from calendar season j .

P = Practice factor – constant raster (Refer to Table 1).

FS = Fine sediment proportion – raster (Refer to Soil Sampling Plan, 3.4.1).

$HSDR$ = Hillslope sediment delivery ratio – 10%.

BAF = Benefit attenuation factor.

CS = Cell area of pixel in hectares (At time of publication: 30m x 30m cell – 0.09ha).

Additional, catchment specific factors (e.g. *Rock Factor*) to be included where available, appropriate and approved by the secretariat.

To be eligible for ACWIS Credits, *FSA_r* must be greater than zero during the monitoring period.

5.7 Accounting for leakage

(Calculation of change in pollutant to at risk asset)

When leakage is considered ‘likely’, project accounting must include the steps detailed in Section 2.6. The following equation is used to calculate FS run-off through RUSLE.

Equation 22 – Project Area FS abatement for the monitoring period accounting for leakage (*FSA*)

Accounting for likely leakage in Project Areas outside the CAZ:

$$FSA = \begin{cases} FSA_r, & FSAI \leq 0 \\ FSA_r - FSAI, & FSAI > 0 \end{cases}$$

Where:

FSA = FS abatement, in tonnes, exported to the at-risk asset of concern for monitoring period, *r* accounting for leakage.

FSA_r = The FS abatement, in tonnes, within the CAZ.

FSAI = The FS loss, in tonnes, within Project Areas outside the CAZ (sediment export calculated as per CAZ reporting method).

5.8 Accounting for disturbance

Any natural and unmanageable disturbance, for example: fire originating from a neighbouring property, or cyclone, will impact ground cover and crediting. Project proponents may delay reporting on disturbed areas until site recovery has occurred or exclude affected areas from the project calculations for a period of no more than 12 months.

5.9 ACWIS Credit Calculation

(Calculation of monitoring period ACWIS Credits)

Equation 23 – Calculation of ACWIS Credits (*AC_r*)

To determine the quantity of Credits generated by project activities during the monitoring period, apply the following equation:

$$AC_r = \begin{cases} FSA_r C_f, & \text{Leakage not considered likely} \\ FSA C_f, & \text{Leakage considered likely} \end{cases}$$

Where:

AC_r = ACWIS Credits generated in monitoring period, *r*.

FSA_r = FS abatement, in tonnes, exported to the at-risk asset of concern for monitoring period, *r* for the CAZ.

FSA = FS abatement, in tonnes, exported to the at-risk asset of concern for monitoring period, *r* accounting for leakage.

Cf = The conversion factor used to convert FS abatement to an equivalent ACWIS Credit.

If ACr is zero or less than zero, then no credits are issued for the monitoring period. Note, any negative balance of ACWIS Credits must then be brought forward to the next reporting period.

5.10 Uncertainty

Estimates of monitoring period FS savings calculated in accordance with this Method are based on reliable remote sensing data. If the approach outlined in this Method is followed, then no confidence deduction is required to account for uncertainty.

6. Monitoring and Record Keeping Requirements

This section sets out monitoring and record-keeping requirements under this Method for a registered ACWIS Credit Project.

A Monitoring Report must be submitted as a requirement for each monitoring period. The project proponent must document all land management activities, disturbance events that occurred during the monitoring period within the Project Area and monitor the Project Area for continued compliance with the eligibility requirements of the Method (Section 2) and with the GLM Plan (Section 4).

The monitoring report must include (as minimum):

- Measurements of pasture biomass and forage budgets if stated in the GLM Plan; and
- Grazing charts, or similar that demonstrate cattle numbers and their movements and periods of rest (spelling) if stated in the GLM Plan; and
- Records of any other activity stated in the GLM Plan; and
- Disturbance events including polygon shapefiles of the event boundaries; and
- Broadscale clearing event including polygon shapefiles of the event boundaries.

Records must be kept (and provided with each monitoring report) in relation to each of the mapping and data requirements set out in Section 3, including but limited to:

- CAZ boundaries; and
- Disturbance event boundaries; and
- Soil sampling locations; and
- Rainfall monitoring location/s, records, initial calibration, and verification.

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