

CARBOTURA

ACM Manufacturing Center

Carbon Dioxide Removal Methodology Document

Puro.earth MC2.1-aligned methodology for Durable Carbon Storage (CRB family, 21 products) and CO2 Mineralisation (MIN-004 PCC). Pre-submission draft for registry review.

Document Class: **Room 2 — Technical Portal (NDA Required)**

Version: CMD-001 Rev 1.0 — Pre-Submission Draft

Registry target: **Puro.earth | Pathway 1: MC2.1 Durable Carbon Storage | Pathway 2: Mineralisation**

PRE-SUBMISSION DRAFT — Design-Basis Methodology

This document presents the CDR accounting methodology for the Carbotura ACM Manufacturing Center at design stage. All quantitative figures are design-basis estimates. This document is structured for Puro.earth MC2.1 review but has not yet been submitted. Third-party verification will follow commissioning. Not for public distribution.

1. Overview and Scope

This document defines the carbon dioxide removal (CDR) accounting methodology for two distinct CDR pathways operated by the Carbotura ACM (Advanced Circular Manufacturing) Manufacturing Center:

- Pathway A — Durable Carbon Storage (CRB family): permanent sequestration of biogenic carbon in 21 stable solid carbon products, from raw carbon char (CRB-001) to single-layer graphene (CRB-015). Registry target: Puro.earth MC2.1 Durable Carbon Storage.
- Pathway B — CO2 Mineralisation (MIN-004): permanent sequestration of captured CO2 in calcium carbonate mineral lattice via the PCC production module. Registry target: Puro.earth Mineralisation category.

Both pathways operate within the same facility boundary. They are accounted separately because they involve different carbon pools (feedstock-derived solid carbon vs. captured process CO2), different permanence mechanisms (crystalline/amorphous solid vs. mineral lattice), and different registry methodologies.

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Version	Rev 1.0 — Pre-Submission Draft
Classification	Room 2 — Technical Portal — NDA Required
Registry target	Puro.earth (primary); Verra VM0044 (alternative for Pathway B)
Anchor documents	FEP-001 Facility Environmental Profile v1.0; CR-001 Claims Register v1.0
CDR pathways	Pathway A: CRB family (21 products); Pathway B: MIN-004 PCC
Facility	Carbotura ACM Manufacturing Center, 100/400/1,000/2,000 TPD configurations

2. Pathway A — Durable Carbon Storage (CRB Family)

Puro.earth MC2.1 Alignment

Pathway A is structured to meet Puro.earth's Durable Carbon Storage methodology criteria: additionality, permanence (>1,000 years or best achievable), measurability, leakage accounting, and monitoring plan. The criteria are addressed in Sections 2.1–2.7.

2.1 Carbon Source and Biogenic Fraction

The manufacturing feedstock entering the Carbotura facility contains carbon from two distinct origins that require separate accounting:

Biogenic Carbon (CDR-eligible)

Biogenic carbon originates from recently living organisms: paper, cardboard, food waste, natural textiles, wood, and biomass fractions of the manufacturing feedstock stream. This carbon was fixed from atmospheric CO₂ by photosynthesis within decades and is part of the active biogenic carbon cycle. Under IPCC 2006 Guidelines and standard LCA practice (GHG Protocol), biogenic carbon in waste streams is treated as atmospheric carbon at the point of entry to a facility.

When biogenic carbon is permanently sequestered in a durable solid carbon product (Pathway A) rather than returning to the atmosphere via decomposition or combustion, the net effect is a removal of CO₂ from the atmosphere — a genuine CDR outcome. This is the basis of the CDR claim for the CRB family.

Typical biogenic carbon fraction: 35–55% of total manufacturing feedstock carbon (design-basis; site-specific measurement required at commissioning)

Measurement method: ASTM D6866 radiocarbon analysis (14C/12C ratio) — the accepted international standard for biogenic content determination in mixed organic materials

Frequency: Quarterly feedstock characterisation during operations; monthly during first year

Fossil Carbon (Avoided-Emission — not CDR)

Fossil carbon originates from petroleum-derived materials: plastics (polyethylene, polypropylene, PET, polystyrene, PVC), synthetic rubber, synthetic textiles, and fossil-derived coatings. This carbon is not part of the active biogenic cycle and does not qualify as CDR under current Puro.earth MC2.1 criteria.

However, fossil carbon permanently sequestered in CRB products represents avoided fossil carbon emission — the carbon that would have been released as CO₂ during landfill gas generation or combustion is instead locked in the product. This is accounted separately as an avoided emission credit, not as a CDR credit. The two must not be conflated.

Summary: Only the biogenic carbon fraction of the CRB products' carbon content qualifies as CDR under Puro.earth MC2.1. The fossil carbon fraction of the same products qualifies as avoided fossil emission — a separate credit category with potentially different pricing and registry requirements.

2.2 Additionality Argument

Additionality requires that the CDR activity would not have occurred without the specific CDR-motivated intervention — i.e. the sequestration is not "business as usual."

Regulatory Additionality

No regulatory requirement exists (at facility design date) mandating the conversion of manufacturing feedstock to durable carbon products. Manufacturing feedstock disposal via landfill or conventional combustion (waste-to-energy) is the regulated and commonly practised alternative in all US jurisdictions. The Carbotura CDR pathway is additional to regulatory requirements.

Financial Additionality

The Carbotura facility produces 116 saleable products. The CRB family products are commercially valuable independently of CDR credits (graphite, activated carbon, and advanced carbon nanomaterials have established markets). The CDR credit revenue is a supplementary revenue stream — it is not the primary financial driver of the facility.

Under Puro.earth MC2.1, financial additionality does not require CDR credits to be the sole or primary revenue source. The requirement is that the activity would not occur in the same form without CDR recognition — satisfied here because the specific combination of high-purity graphitisation at 3,000°C and rigorous carbon accounting is motivated in part by the CDR credential.

Technical Additionality

Conventional waste processing (landfill, mass-burn WtE) does not produce durable carbon products. The conversion of manufacturing feedstock organic carbon to >99.9% purity crystalline graphite requires the Recyclotron MCR process and the Regensis MAX electromagnetic graphitisation train — technology not deployed in any existing conventional waste processing facility. The pathway is technically additional by design.

2.3 Permanence Assessment

Permanence under Puro.earth MC2.1 is assessed against a 1,000-year threshold (or best achievable). Different CRB products have different permanence profiles. The register below classifies each product tier:

Product Tier	Representative Products	Carbon Structure	Permanence Assessment	Expected Lifetime
Crystalline graphite	CRB-008, CRB-012, CRB-018	Hexagonal graphite lattice, d002 <0.337 nm	Geologically stable. Graphite is the equilibrium form of solid carbon. Natural graphite deposits persist for 100s of millions of years. Equivalent to geological coal in stability.	>1,000 years — meets threshold
Advanced	CRB-013, CRB-014, CRB-	sp2 hexagonal	Chemically inert	>1,000 years

graphene derivatives	015	carbon, near-perfect lattice	under ambient conditions. High surface energy but thermodynamically stable. No degradation pathway under normal storage conditions.	— meets threshold
Carbon nanotubes	CRB-011, CRB-016	Closed sp2 graphene cylinders	Extremely high tensile strength. No oxidative degradation below 400°C. Stable in ambient environment.	>1,000 years — meets threshold
Hard carbon / semi-graphitic	CRB-005, CRB-019, CRB-021	Turbostratic, partially ordered	Stable under ambient conditions. Oxidation onset >300°C. Conservative estimate 500–1,000 years under normal storage. Less than crystalline graphite.	500–1,000 years — partial credit or conservative
Activated / amorphous carbon	CRB-001, CRB-002, CRB-003	Disordered / microporous amorphous carbon	Stable under ambient conditions. More surface area = more potential oxidation but very slow at ambient temperature and pressure. Conservative estimate: 100–500 years.	100–500 years — below 1,000-year threshold
Biochar (CRB-004)	CRB-004	Pyrogenic carbon, heterogeneous	Soil application is the primary use case. In soil, biochar degrades slowly (decades to centuries depending on soil conditions). IBI / EBC biochar certification standards apply.	100–500 years in soil — EBC/IBI methodology preferred

Permanence Classification Decision

For Puro.earth MC2.1 submission, Carbotura proposes the following permanence classification: (1) Crystalline graphite and graphene/CNT products (CRB-005 through CRB-018 graphitic tier, CRB-011 through CRB-017): classified as ≥1,000 year durable carbon — full CDR credit. (2) Hard carbon products (CRB-019, CRB-020, CRB-021): classified as 500–1,000 year durable carbon — conservative discounting to be agreed with Puro.earth during methodology review. (3) Amorphous and activated carbon (CRB-001, CRB-002, CRB-003): classified as <1,000 year — eligible for partial CDR credit under permanence discounting per Puro.earth guidelines, or claimed as avoided-emission only. (4) Biochar (CRB-004): IBI/EBC biochar certification pathway, separate from Puro.earth MC2.1.

2.4 Carbon Quantification Methodology

The quantity of carbon sequestered per tonne of CRB product is calculated as follows:

Step 1 — Total Carbon Content

Total carbon content of each CRB product is determined by ASTM C711 (Standard Test Method for Low-Temperature and High-Temperature Ash of Analysis Samples of Coal and Coke) elemental analysis. For high-purity graphite (CRB-008, CRB-012, CRB-018): carbon content >99.9% w/w. For lower-RC products: carbon content measured per product specification.

$$C_{total} = product_mass (t) \times carbon_content_fraction (w/w)$$

Step 2 — Biogenic Fraction Determination

The biogenic fraction of the carbon in each CRB product is determined by ASTM D6866 radiocarbon analysis (14C/12C ratio). Modern carbon (pMC) values above background indicate biogenic fraction; depleted values indicate fossil fraction.

$$C_{biogenic} = C_{total} \times biogenic_fraction (ASTM D6866)$$

Step 3 — CDR Credit Calculation

The CDR credit is the biogenic carbon permanently sequestered, expressed as CO₂ equivalent:

$$CDR_credit (t CO_2e) = C_{biogenic} (tC) \times (44/12) \times permanence_factor$$

Where: 44/12 = molecular weight ratio CO₂/C; permanence_factor = 1.0 for ≥1,000 year products, or discounted per Puro.earth guidelines for <1,000 year products.

Step 4 — Avoided-Emission Credit (Fossil Carbon, Separate)

For the fossil carbon fraction of CRB products, an avoided-emission credit is calculated representing the CO₂ that would have been emitted from the counterfactual scenario (landfill decomposition or combustion). This is not a CDR credit but is reported separately in the facility GHG inventory.

$$Avoided_emission (t CO_2e) = C_{fossil} (tC) \times (44/12) \times counterfactual_emission_factor$$

2.5 Baseline Scenario

The baseline scenario represents the most likely fate of the manufacturing feedstock in the absence of the Carbotura facility. Two baselines are evaluated:

Baseline A — Sanitary Landfill (Primary Baseline)

In the primary baseline, manufacturing feedstock is disposed of in a sanitary landfill. The organic fraction decomposes anaerobically, generating landfill gas (approximately 50% CH₄, 50% CO₂ by volume). Landfill gas collection efficiency in modern US landfills is approximately 50–75%. Uncollected CH₄ is emitted to atmosphere at GWP-100 = 27.9 (IPCC AR6).

Baseline methane emission factor: EPA AP-42 Chapter 2.4: 0.5–1.0 t CH₄ per tonne of organic waste landfilled (depending on organic content and decomposition rate)

Baseline CO₂e (landfill): Approximately 0.4–0.8 t CO₂e per tonne of manufacturing feedstock (direct landfill gas emissions, 50% collection efficiency)

Avoided landfill methane (system expansion): The Carbotura scenario eliminates this baseline emission entirely — the organic fraction does not decompose because it is converted to product

Baseline B — Mass-Burn WtE (Secondary Baseline)

In the secondary baseline, manufacturing feedstock is combusted in a mass-burn waste-to-energy facility. Carbon is oxidised to CO₂. The CDR credit from permanent sequestration in CRB products is assessed relative to the WtE combustion baseline: every tonne of carbon sequestered in a CRB product represents avoided CO₂ emission relative to the combustion scenario.

Baseline CO₂e (WtE combustion): Approximately 0.3–0.7 t CO₂ per tonne of manufacturing feedstock (carbon content × oxidation factor)

The Carbotura facility outperforms both baselines on net carbon outcome by design. The primary CDR accounting uses Baseline A (landfill) as it represents the majority of current US manufacturing feedstock disposal.

2.6 Leakage Accounting

Leakage occurs when CDR activity causes additional emissions elsewhere that would not have occurred without the activity. Three potential leakage pathways are assessed:

Market Leakage (Upstream Displacement)

The Carbotura facility substitutes for conventional waste disposal (landfill or WtE). Reduced landfill tipping results in marginal reduction in landfill construction and operation — a net positive (less landfill = less methane). No upstream leakage from material supply, as manufacturing feedstock is generated independently of the Carbotura facility.

Market leakage assessment: Negligible to positive. Manufacturing feedstock generation is not induced by the Carbotura facility.

Activity Leakage (Facility Emissions)

Facility operations generate Scope 1 emissions (primarily from Pregenesis material handling). These are directly accounted in the net CDR calculation as a deduction from gross CDR credits (see Section 2.4). No additional leakage pathway from facility operations.

Activity leakage: Fully accounted — deducted from gross CDR credits in Step 3.

Product End-of-Life Leakage

If CRB products are subsequently combusted or decomposed at end-of-life, the sequestered carbon would be re-released. The permanence assessment (Section 2.3) addresses this risk. For products with verified permanence >1,000 years (crystalline graphite, CNTs, graphene), end-of-life leakage is negligible. For lower-permanence products, permanence discounting in the credit calculation (Section 2.4 Step 3) conservatively accounts for this risk.

Product end-of-life leakage: Addressed via permanence discounting. No additional leakage deduction.

2.7 Monitoring, Reporting and Verification (MRV) Plan

The following monitoring plan applies to Pathway A from commissioning:

Parameter	Method	Frequency	Responsible Party
Feedstock biogenic fraction (ASTM D6866)	14C radiocarbon analysis of quarterly composite feedstock sample	Quarterly	Accredited third-party laboratory
CRB product carbon content	ASTM C711 elemental analysis per product batch	Per production batch (monthly minimum)	Accredited third-party laboratory
CRB product crystallographic quality (ASTM C781)	XRD analysis — d002 spacing, Lc, La crystallite size	Quarterly per product tier	Accredited materials laboratory
CRB product mass output	Calibrated belt scale at each CRB module output	Continuous (per shift)	Facility instrumentation
Facility Scope 1 emissions	Point-source CEMS at Pregenesis sorting train exhaust	Continuous	Facility instrumentation
Annual CDR credit calculation	Compile above data per Section 2.4 formula	Annual (calendar year vintage)	Carbotura CDR team + Puro.earth verifier
Third-party verification	Independent review of monitoring data and credit calculation	Annual	Puro.earth-approved verifier

2.8 Pathway A CDR Potential Summary

Design-basis CDR potential for the CRB family at four facility configurations:

Configuration	Total CRB Output (t/day)	Est. Biogenic Fraction (45%)	Gross CDR (t CO2e/yr)	Net CDR after Scope 1 deduction
100 TPD	~50 t/day	~22.5 t C/day biogenic	~28,800 t CO2e/yr	~27,800 t CO2e/yr
400 TPD	~200 t/day	~90 t C/day biogenic	~115,200 t CO2e/yr	~111,200 t CO2e/yr
1,000 TPD	~500 t/day	~225 t C/day biogenic	~288,000 t CO2e/yr	~278,000 t CO2e/yr
2,000 TPD	~1,000 t/day	~450 t C/day biogenic	~576,000 t CO2e/yr	~556,000 t CO2e/yr

These figures use: biogenic fraction = 45% (midpoint design-basis); permanence factor = 1.0 for graphitic products (representing ~60% of CRB output by mass); conservative discounting for lower-permanence products. All figures are design-basis estimates. Actual figures depend on feedstock biogenic characterisation at each facility site.

3. Pathway B — CO₂ Mineralisation (MIN-004 PCC)

Puro.earth Mineralisation Alignment

Pathway B sequesters CO₂ captured from the Recyclotron syngas cleanup train into calcium carbonate mineral lattice via the MIN-004 Precipitated Calcium Carbonate (PCC) production module. The permanence mechanism is mineral crystallisation — geologically stable on timescales exceeding 10 million years.

3.1 Process Description

CO₂ captured in the Carbotura gas cleanup train (GAS-003 Industrial CO₂, ≥99.5% CO₂) is piped to the MIN-RC3-PCC module. There it reacts with calcium hydroxide (Ca(OH)₂, slaked lime) in a controlled carbonation reactor to produce precipitated calcium carbonate (PCC):



The reaction is exothermic and proceeds rapidly at ambient temperature and pressure with CO₂ at near-atmospheric pressure. The CaCO₃ product precipitates as a fine powder (calcite, aragonite, or vaterite crystal form depending on reactor conditions) and is filtered, dried, and packaged as MIN-004 PCC.

Molecular weights: CO₂ = 44.01 g/mol; Ca(OH)₂ = 74.09 g/mol; CaCO₃ = 100.09 g/mol; H₂O = 18.01 g/mol

Stoichiometric CO₂ uptake: 44.01/100.09 = 0.4397 ≈ 440 kg CO₂ per tonne of CaCO₃ produced

Reaction conversion target: >95% CO₂ conversion per pass (reactor design basis)

3.2 CO₂ Source Characterisation

The CO₂ entering the MIN-RC3-PCC module originates from GAS-003, which is separated from the Recyclotron MCR syngas output. The CO₂ in the syngas has three possible origins:

- Biogenic CO₂: from combustion / reformation of biogenic organic fraction of feedstock (paper, food, biomass). This CO₂ was recently atmospheric — its mineralisation constitutes CDR.
- Fossil CO₂: from reformation of fossil-derived organic fraction (plastics). This CO₂ was fossil-origin — its mineralisation constitutes avoided fossil emission (not CDR under current registry methodologies).
- Inorganic CO₂: from decomposition of carbonate minerals in the feedstock (limestone, concrete). This CO₂ was geological-origin — neutral (not CDR or avoided emission).

The biogenic fraction of GAS-003 CO₂ must be characterised by the same ASTM D6866 radiocarbon method used for CRB products (Section 2.1). The CDR credit for MIN-004 applies only to the biogenic CO₂ fraction.

Design-basis biogenic CO₂ fraction in GAS-003: 35–55% (same as feedstock biogenic fraction, since CO₂ production is proportional to carbon content of feedstock fractions)

CDR-eligible CO2 mineralised (design-basis): 0.440 t CO2/t PCC × biogenic fraction ≈ 0.154–0.242 t CO2 CDR per tonne of MIN-004 PCC

Avoided-emission CO2 mineralised (design-basis): 0.440 t CO2/t PCC × fossil fraction ≈ 0.198–0.286 t CO2 avoided per tonne of MIN-004 PCC

3.3 Additionality

The carbonation of captured CO2 with calcium hydroxide to produce PCC is an established industrial process (the dominant commercial PCC production route). Additionality is established by the source of CO2:

In conventional PCC production, CO2 is sourced from fossil-fuel combustion flue gas or from industrial CO2 suppliers (themselves derived from fossil sources). In the Carbotura process, the CO2 is captured from the facility syngas — a CO2 stream that would otherwise be (a) vented as facility emissions in a conventional process, or (b) re-combusted in the facility energy system.

The Carbotura facility does not vent CO2 (Section 2.3 of FEP-001). Therefore, the counterfactual for GAS-003 CO2 is not "released to atmosphere" but rather "sold as GAS-003 Industrial CO2 to third-party buyers who would otherwise use fossil-derived CO2." The mineralisation pathway (Pathway B) permanently sequesters this CO2 that would otherwise re-enter the carbon cycle.

Additionality basis: Geological permanence of mineral CaCO3 relative to industrial CO2 gas (which re-enters the carbon cycle on industrial timescales)

3.4 Permanence

Calcium carbonate (calcite) is one of the most stable minerals in Earth's crust. Natural limestone (predominantly CaCO3) has geological ages measured in hundreds of millions of years. Under ambient temperature, pressure, and neutral-to-alkaline pH conditions, CaCO3 dissolution is negligible.

Permanence mechanism: Mineral crystallisation — CO2 covalently bonded in carbonate (CO3²⁻) lattice of CaCO3 crystal

Dissolution risk: CaCO3 dissolves in acidic conditions (pH < 6). Mitigation: product specification requires storage and application in neutral-to-alkaline environments (concrete, paper, plastic filler — all alkaline or neutral pH)

Permanence assessment: >1,000 years under design use conditions — meets Puro.earth threshold

Verification: XRD crystal structure confirmation (calcite/aragonite phase purity) per ASTM E1876 or equivalent

3.5 Quantification

MIN-004 PCC CDR credit calculation:

$$\text{CDR_credit (t CO2e)} = \text{PCC_mass (t)} \times 0.440 \text{ (stoichiometric)} \times \text{biogenic_fraction (ASTM D6866)}$$

Example at 100 TPD facility: PCC output = 0.5 TPD × 350 days = 175 t/yr. At 45% biogenic fraction: $175 \times 0.440 \times 0.45 = 34.7$ t CO₂ CDR/yr

Example at 400 TPD facility: $700 \text{ t/yr} \times 0.440 \times 0.45 = 138.6$ t CO₂ CDR/yr

The MIN-004 CDR volume is modest relative to Pathway A (CRB). Its significance is the quality of the permanence argument — mineral CaCO₃ is arguably the most durable sequestration medium in the Carbotura product portfolio — and the exact stoichiometric quantifiability (440 kg CO₂/t is deterministic, not modelled).

3.6 MRV Plan — Pathway B

Parameter	Method	Frequency	Responsible Party
GAS-003 CO ₂ volume captured	Calibrated flow meter on GAS-003 line to MIN-RC3-PCC	Continuous	Facility instrumentation
GAS-003 biogenic CO ₂ fraction	ASTM D6866 radiocarbon analysis of CO ₂ sample	Quarterly	Accredited third-party laboratory
MIN-004 PCC mass output	Calibrated mass balance at MIN module output	Continuous (per batch)	Facility instrumentation
MIN-004 CaCO ₃ purity	ASTM C25 chemical analysis; XRD phase identification	Per production batch	Accredited materials laboratory
CO ₂ conversion efficiency	Inlet CO ₂ vs. CaCO ₃ mass balance per Section 3.5	Monthly	Carbotura CDR team
Annual CDR credit calculation	Compile above data per Section 3.5 formula	Annual	Carbotura CDR team + verifier

4. Combined CDR Accounting

4.1 Consolidated CDR Summary (100 TPD Design Basis)

Component	Gross CDR (t CO ₂ e/yr)	Deductions	Net CDR (t CO ₂ e/yr)	Registry
Pathway A — CRB biogenic carbon sequestration	~28,800	Scope 1 facility emissions: ~(1,000)	~27,800	Puro.earth MC2.1
Pathway B — MIN-004 CO ₂ mineralisation	~35	None (self-contained)	~35	Puro.earth Mineralisation
Avoided landfill methane (system expansion)	~8,000–14,000	N/A — system expansion credit, not direct CDR	~8,000–14,000	LCA / GHG inventory
TOTAL — direct CDR (Pathways A + B)	~28,835	~(1,000)	~27,835 t CO ₂ e/yr	Puro.earth
TOTAL — system expansion (direct + avoided CH ₄)	~36,835–42,835	~(1,000)	~35,835–41,835 t CO ₂ e/yr	ISO 14044 LCA

The avoided landfill methane credit is a system expansion credit per ISO 14044 §4.3.4. It is reported in the facility GHG inventory and the Facility Environmental Profile (FEP-001) but is not a Puro.earth registry credit. It is included here for completeness. The Puro.earth submission covers only Pathways A and B direct CDR (~27,835 t CO₂e/yr at 100 TPD design basis).

4.2 Vintage Structure

CDR credits are issued as annual vintages. The first vintage covers the first full calendar year of commercial operations (Year 1 post-COD). Pre-commercial commissioning CDR is not credited.

- Vintage period: January 1 – December 31 (calendar year)
- Credit issuance: following third-party verification of annual monitoring data (typically Q1 of following year)
- Retirement timeline: per Puro.earth standard (credits must be retired within 5 years of issuance)
- Buffer pool contribution: per Puro.earth MC2.1 requirements (typically 20% of gross credits held in buffer for permanence risk)

4.3 Interaction Between Pathways

Pathways A and B are physically independent — they process different carbon streams (solid organic carbon vs. captured gaseous CO₂) through different process modules. The same carbon atom cannot appear in both pathways. The only interaction is that both use energy from the same PEM fuel cell stack — but since the PEM stack produces zero Scope 2 emissions, this shared energy source does not create any double-counting risk in the CDR accounting.

5. Registry Submission Plan

Primary registry target	Puro.earth — Durable Carbon Storage (Pathway A); Mineralisation (Pathway B)
Alternative registry	Verra VCS VM0044 (Enhanced Rock Weathering / Mineralisation — Pathway B alternative if Puro.earth mineralisation methodology is not applicable at submission date)
Pre-submission action	Submit this methodology document to Puro.earth for informal review before commissioning. Request written feedback on: (1) permanence classification for hard carbon tier; (2) biogenic fraction accounting methodology; (3) avoided landfill methane treatment.
Verification body	Puro.earth-approved third-party verifier — selection pending. Initial shortlist: South Pole, Climate Consulting, Intertek Carbon.
First submission date	Q3 of Year 1 post-COD — following commissioning and first six months of operational monitoring data
Credit pricing expectation	Design-basis \$80–150/t CO ₂ e for durable carbon storage (Puro.earth market range at document date)
Buffer pool requirement	~20% of gross credits held in Puro.earth buffer pool (standard permanence risk requirement)
Key open questions for Puro.earth review	(1) Permanence discount factor for hard carbon / turbostratic products. (2) Treatment of fossil carbon fraction — separate avoided-emission credit or excluded? (3) Biogenic fraction methodology (ASTM D6866) acceptance. (4) System boundary for GAS-003 biogenic CO ₂ fraction (Pathway B).

6. Document Control

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Pathways covered	Pathway A: CRB family Durable Carbon Storage (21 products); Pathway B: MIN-004 CO2 Mineralisation
Related documents	FEP-001 Facility Environmental Profile v1.0; CR-001 Claims Register v1.0; LCA Methodology Framework v1.0 (pending)
Next revision	Rev 2.0 following Puro.earth methodology review feedback; Rev 3.0 post-commissioning incorporating actual feedstock biogenic fraction data

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