

Quality Assurance and Quality Control of Ocean Asset Accounts

Sets out the checks, records and independent review that show an ocean asset account – physical or monetary, individual resource or ecosystem – is complete, balanced and fit to publish.

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OUTCOME

After working through this Circular, you will be able to show that an ocean asset account is complete, balanced and fit to publish, and to hand a reviewer the evidence that confirms it. You will be able to:

- write a quality assurance and quality control (QA/QC) plan for an asset account: the generic core every account needs, and the asset-account part;
- run and log the general checks and the asset-type acceptance checks, physical and monetary;
- reconcile the account with the supply and use tables, the production account, government finance statistics, the greenhouse gas inventory and the national balance sheet;
- give every cell a grade and a status, and carry them into aggregates;
- quantify the uncertainty in asset values and report it as a range;
- pass independent review with a complete evidence pack.

The Circular sets no accounting rule of its own. Every rule it tests is owned by the circular named beside the check, most often [TG-3.1 Asset Accounts](#); what this Circular adds is the procedure, the tolerance and the record.

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ABOUT THIS CIRCULAR**RECOMMENDED CITATION**

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1. Outcome

¶1 After working through this Circular, you will be able to show that an ocean asset account is complete, balanced and fit to publish, and to hand a reviewer the evidence that confirms it. You will be able to:

- ¶2 write a quality assurance and quality control (QA/QC) plan for an asset account: the generic core every account needs, and the asset-account part;
- ¶3 run and log the general checks and the asset-type acceptance checks, physical and monetary;
- ¶4 reconcile the account with the supply and use tables, the production account, government finance statistics, the greenhouse gas inventory and the national balance sheet;
- ¶5 give every cell a grade and a status, and carry them into aggregates;
- ¶6 quantify the uncertainty in asset values and report it as a range;
- ¶7 pass independent review with a complete evidence pack.

¶8 The Circular sets no accounting rule of its own. Every rule it tests is owned by the circular named beside the check, most often **TG-3.1 Asset Accounts**; what this Circular adds is the procedure, the tolerance and the record.

2. Requirements

¶1 **Essential prerequisites:**

- ¶2 **TG-0.1 General Introduction to Ocean Accounts**: conceptual framework and the three-domain structure
- ¶3 **TG-0.7 Quality Assurance Principles**: quality dimensions, uncertainty categories, documentation categories and quality flags
- ¶4 **TG-3.1 Asset Accounts**: the asset account tables, identities and compilation procedure that the checks test

¶5 **Helpful background:**

- ¶6 **TG-2.1 Aggregate Biophysical Indicators of Environmental State**: condition rescaling and aggregation
- ¶7 **TG-1.9 Safe Usage of Monetary Valuation** and **TG-2.4 Environmental (including Ecosystem) Goods and Services** Section 3.10: valuation choices and service-level methods
- ¶8 **TG-4.1 Remote Sensing and Geospatial Data** and **TG-2.12 Spatial Data Frameworks**: extent accuracy and the spatial rules
- ¶9 **TG-4.8 Physical Condition Measurement** and **TG-4.9 Biological Condition Measurement**: condition variables
- ¶10 **TG-6.7 Fisheries Accounting: Integrating Stock Assessment**: the stock assessment behind the fish account
- ¶11 **TG-0.8 Implementation Readiness Assessment**: the institutional checklist (Section 3.5.2)

¶12 ① **Framework Position**

¶13 This Circular addresses the stock side of the Ocean Accounts Framework, at the same edges as TG-3.1: the asset accounts that record SNA produced assets (SG1) and environmental assets (SG3). In the Ocean Accounts Framework (TG-0.1 Figure 0.1.2):

Edge	Direction	Description
E3	FG1 ↔ SG1	Economic flows interacting with SNA assets (Applied)
E9	SG3 → FG1	Environmental assets supplying ecosystem services to economy (Applied)
E11	FG3 ↔ SG3	Environmental assets supporting intermediate ecosystem services (Applied)

¶14 **Scope.** TG-3.16 owns the QC procedure, the tolerances and the evidence for the asset account tables of TG-3.1, and the reconciliations between those tables and the accounts beside them. It covers asset accounts only. The QC of the other Section 3 accounts – flows (**TG-3.2**, **TG-3.4**), economic activity (**TG-3.3**), social (**TG-3.5**) and governance (**TG-3.7**) accounts, and combined presentations (**TG-3.8**) – sits with TG-0.7 and the circular that owns each account; TG-3.16 meets them only where they reconcile with an asset cell (Section 3.6). It sets no accounting rule of its own and records no account entry, so it shares none.

3. Guidance Material

¶1 An asset account can balance and still be wrong. The identity *opening + additions – reductions = closing* holds in any account whose compiler has closed it on a residual, and a residual can absorb a dropped conversion, a double-counted loss or a unit slip without trace. The worked example in Section 3.8 carries nine seeded errors, and every column in it balances. The identity is necessary, and it is the first check; it is not sufficient, and the rest of this Circular is about what else has to be tested.

3.1 Concepts, Scope and Layers

¶1 ⚠ **Interim defaults pending Secretariat decision**

¶2 Four conventions this Circular depends on are not yet settled. Until they are, it uses these defaults, and comments on them are invited: a two-field flag of grade and status (C2, Section 3.7); the uncertainty ladder of Section 3.9 at 95% (C3); exchange values only, one carbon price per account (C4, AQ-VA6), which departs from TG-6.2 Section 3.6, where the social cost of carbon is accepted for carbon retention; and the indicative tolerances of Tables 3.16.4 and 3.16.5 (C7).

¶3 The three terms below are used in the IPCC sense throughout (Table 3.16.1)¹. They separate who performs a check from what it is compared against, and the separation is what makes a review independent.

Term	Performed by	Compares the account with
Quality control (QC)	The compilers, routinely, during compilation	Its own inputs, identities and rules
Quality assurance (QA)	People not involved in compiling it	The evidence pack, by recomputation and review
Verification	Either, using methods external to the account	Independent data: a global product, another assessment, a neighbouring account

¶4 *Table 3.16.1: Terms, after IPCC (2006) Volume 1 Chapter 6 Box 6.1.*

¶5 **Scope.** The checks apply to the asset accounts of TG-3.1, physical and monetary, as the Framework Position sets out: SEEA CF individual environmental assets (coastal aquifers only for water), SEEA EA extent, condition and monetary ecosystem assets, and produced assets only where they touch environmental assets.

¶6 **Basis.** No SEEA publication gives a quality assessment framework of its own. The SEEA EA sets out the quality dimensions and the uncertainty categories (paras 2.86–2.95), points compilers to the IMF Data Quality Assessment Framework (para 2.89), and lists the articulation of data quality assessment frameworks in its research agenda as work still to do². The SEEA Central Framework treats quality as data confrontation: putting estimates into an accounting framework exposes their inconsistencies (paras 1.54, 6.7, 6.86), and revisions are “standard practice” (para 6.68)³. This Circular therefore draws the procedure from general frameworks the SEEA points to: UN-NQAF requirement 15.1, that source data, intermediate results and outputs are regularly assessed and validated⁴; IMF DQAF element 3.4, validation of intermediate data and outputs⁵; and GSBPM v5.2 sub-processes 5.3 (review and validate) and 6.2 (validate outputs)⁶.

¶7 **Layers.** The Circular follows the pattern the IPCC inventory guidelines use for the same problem: general procedures are written once, and category procedures sit with the category¹. TG-0.7 holds the principles; for this consultation TG-3.16 also carries the generic QC core (Section 3.2). TG-3.16 holds QC for the asset-account category, shared by TG-3.1 and the Section 6 circulars that populate asset accounts. TG-3.1 and each Section 6 circular keep their rules, and list in their own quality subsection only the checks distinctive to them. Figure 3.16.1 places each kind of check in the statistical production process.

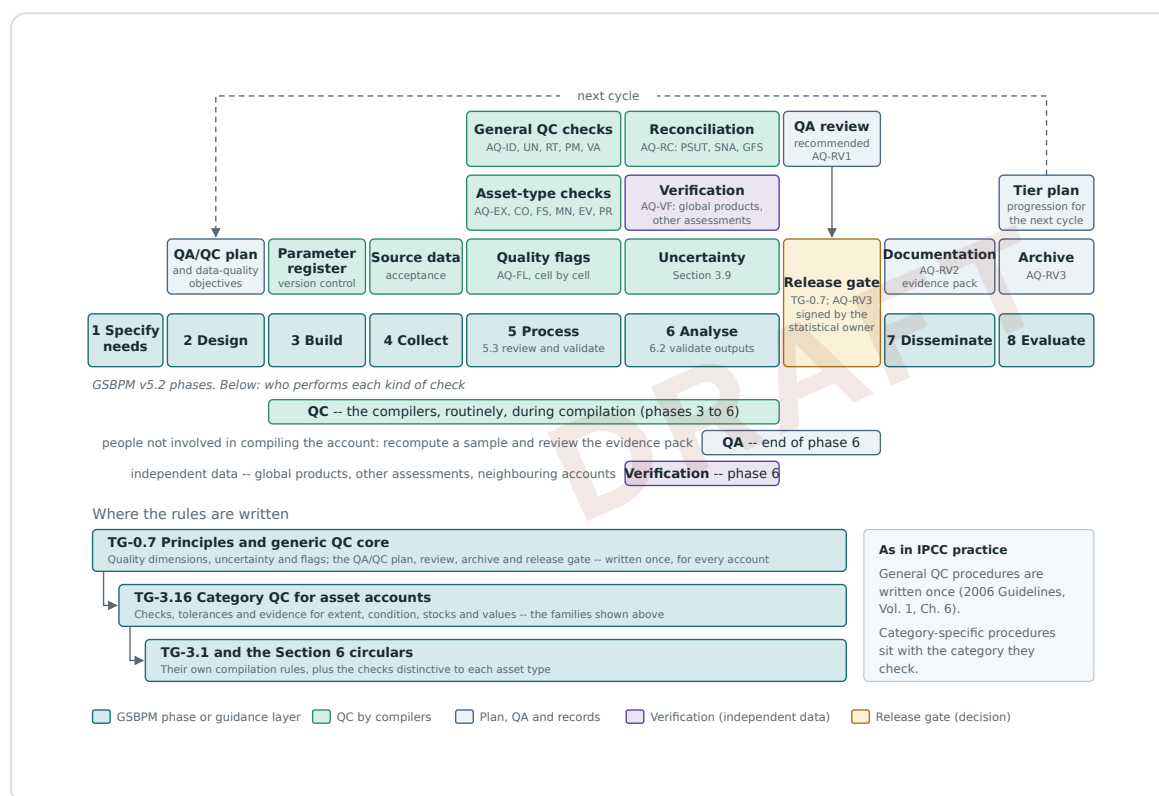


Figure 3.16.1 QC runs inside compilation; QA and verification sit at its end, and the release gate closes it. General rules are written once in TG-0.7, asset-account checks in TG-3.16, and distinctive checks in the owning circulars, as IPCC practice does. Check families are shown, not individual checks.

Source: IPCC (2006) 2006 IPCC Guidelines, Vol. 1, Ch. 6, Box 6.1 and Sections 6.5–6.10; UNECE GSBPM v5.2, sub-processes 5.3 and 6.2; TG-3.16.

Note: Check identifiers carry the prefix AQ- (asset QC); a family such as AQ-ID groups the numbered checks of Tables 3.16.4 and 3.16.5. The tiers of Section 3.2 set which checks are the minimum.

¶8 Check identifiers carry the prefix **AQ-** (asset QC), so a QC log can cite *AQ-ID3* without ambiguity against another circular’s numbering.

3.2 QA/QC Plan and Data-Quality Objectives

¶1 ⓘ **Generic QC core, carried here for consultation**

¶2 The plan, the roles, the records, QC intensity (this section), independent review, the archive, the release gate and the generic evidence pack (Section 3.10), and the uncertainty ladder (Section 3.9) apply to every ocean account, not only to asset accounts. They are set out here so that this Circular can be read and used on its own during the consultation. After the consultation closes they move to **TG-0.7**, and this Circular will keep only the asset-account application. Comments on where this core should sit are welcome.

¶3 A QA/QC plan is written before compilation starts and names the checks, who runs them and when, the independent reviewer, the release gate, the tolerance register and the data-quality objectives¹. It is the document a reviewer reads first, and it is what TG-0.8's checklist item 8 asks an institution to have adopted. For an asset account the plan also says what each data-quality objective means for assets, which checks each tier runs, and which parameters the parameter register holds (Section 3.3).

¶4 **Roles.** Six roles carry the plan. One person may hold several in a small office, with one exception: the independent reviewer may not also be a compiler.

- ¶5 **Compiler:** runs every QC check in Sections 3.4 to 3.7 and keeps the QC log.
- ¶6 **Data manager:** keeps the source register, metadata, archive and version control.
- ¶7 **QA/QC coordinator:** owns the plan, schedules the reviews and keeps the issue register.
- ¶8 **Independent reviewer:** not involved in compilation (AQ-RV1).
- ¶9 **Statistical owner** (usually the national statistical office): signs off official figures, confidentiality and SDG custodian alignment.
- ¶10 **Community authority:** approves publication of traditional knowledge and community data (**TG-3.6**).

¶11 **Records.** Three records are kept from the first day: the **QC log** (check, cell, result, action, initials, date); the **issue register** (open or closed, and whether each issue blocks release); and the **parameter register**, the single place every parameter is set (Section 3.3).

¶12 **QC intensity.** QC effort scales with tier and with materiality. A representative sample of derived cells may be checked in any one cycle, provided every part of the account is covered over successive cycles¹. Headline figures and every figure quoted in narrative text are recomputed in every cycle, whatever the tier (AQ-UN4).

¶13 **Data-quality objectives.** The plan sets the seven data-quality objectives of the IPCC guidelines¹. For an asset account each means the following (Table 3.16.2), and each needs a national value in the plan.

Objective	What it means for an asset account
Completeness	Every asset type in the accounting area is compiled, or shown as “..” with a reason
Consistency	Every identity closes; the series uses one method or its breaks are logged
Comparability	IUCN GET at level 3 or finer; fixed classification versions; one equal-area CRS
Accuracy	Extent accuracy thresholds met; stock coefficient of variation stated
Timeliness	Release lag after the reference period stated and met
Transparency	Evidence pack complete, including the asset items of Table 3.16.8
Improvement	A tier-progression plan for the next cycle

¶14 *Table 3.16.2: Data-quality objectives for an asset account, after IPCC (2006) Volume 1 Section 6.5.*

¶15 **Tiers.** Tier 1 is the minimum viable approach and higher tiers add rigour, as in TG-0.7 Section 3.8. The tiers here are proposed for consultation:

- ¶16 **Tier 1 (minimum).** AQ-ID1 to AQ-ID4, AQ-ID6, AQ-UN1, AQ-UN4, AQ-PM3, AQ-VA6, AQ-FL1 and one verification check, plus the Table 3.16.5 acceptance checks for every asset type compiled.
- ¶17 **Tier 2.** Every check in Tables 3.16.4 to 3.16.6, with at least 10% of derived cells recomputed.
- ¶18 **Tier 3.** Tier 2, with Monte Carlo uncertainty for every monetary asset and a subject-specialist reviewer for each of the stock, extent and valuation parts.

¶19 The worked example measures what the minimum misses: Tier 1 catches six of the nine seeded errors, and the three it does not catch (net recorded as gross, a condition index applied twice, and a loss valued twice) are the case for Tier 2.

¶20 **QC log template.** Tables 3.16.4 to 3.16.6, with columns added for the result, the action, initials and date, are the template for the QC log. For condition cells the log also records the expected range, its source in the reference-value register, and the range verdict under AQ-CO7 (inside the usual range; unusual but within the plausibility range; or outside it and investigated).

3.3 Methodological Issues

¶1 **Parameter register.** Every parameter that scales a result is set once, in one register, with its source, vintage and owner. For an asset account it holds: the discount rate and horizon, the carbon price and its basis, unit prices and rents, live-weight conversion factors, the carbon-to-CO₂ factor of 44/12, reference levels, the minimum mapping unit and the CRS pair. A value typed into a formula is a finding in itself, because it cannot be changed consistently.

¶2 **Source-data acceptance.** Data from monitoring, research and administrative sources often concentrate on edge or problem cases, and need review against the measurement concepts and scope of the account before use (SEEA EA paras 2.87–2.88)². That review belongs to the Section 4 circular that delivers the variable, with its definition, source, unit, coverage, reference value, uncertainty and quality tier (**TG-0.4** Section 4.5). The account's test is only that each value arrives with those attributes, a flag and its location in the primary source (a table cell or a quotation); a value without them goes back to its Section 4 owner. The location matters because values copied through secondary syntheses drift: an index is re-labelled as a stock, a biomass figure as carbon, or a value measured in another country is attached to a local place name. A value that cannot be traced to its primary source is not entered.

¶3 **Double counting.** Four pairs cause most of it, and each has a check: fish-stock value and provisioning flow (AQ-ID6; **TG-6.7** Section 3.5), produced and ecosystem protection (AQ-PR1), rent and government receipts (AQ-RC4), and nursery services (AQ-VA7).

¶4 **Time series and revisions.** Every revision is documented (SEEA EA para 10.40)⁷, breaks are back-cast where feasible (**TG-0.7** Section 3.2.4), and the asset account revises when and as the national accounts do, so that the two revisions policies stay aligned (SEEA CF para 6.70)³. Table 3.16.3 sets the two cases. A back-revision that moves a published indicator by more than 5% is re-published, the threshold **TG-4.5** Section 3.5.4 sets.

Cause of the revision	Individual environmental asset	Ecosystem extent and condition	Monetary ecosystem asset
New data, same asset, same method	Reappraisal, current period	Reappraisal, shown as an identified line (SEEA EA 4.17) ⁸	Reappraisal (SEEA EA 10.38) ⁹
New method, source, classification or reference level	Benchmark revision at rebasing: restate, back-cast, log the break	Benchmark revision at rebasing: restate, back-cast, log the break	Benchmark revision at rebasing: restate, back-cast, log the break

¶5 Table 3.16.3: Treatment of revisions, aligned with national accounts benchmark revision and rebasing.

3.4 General QC Checks

¶1 Known issues in the TG-3.1 worked example

¶2 Several checks below name TG-3.1 as the owner of their rule. The TG-3.1 worked example does not yet pass all of them, and the corrections are scheduled for the revision after this consultation: a reclassification is not shown in Table 5 (AQ-ID4); storm damage is booked as catastrophic loss within the regrowth horizon (AQ-RT1); restoration is valued as enhancement before the survival check (AQ-RT4); the seagrass linear-shortcut test is applied below its 70% condition (AQ-VA3); and depletion is equated with extraction (AQ-PM3). Read the TG-3.1 rules, not its example, until then.

¶3 The general checks apply to every asset account, whichever asset type it holds (Table 3.16.4). They are written in the style of the IPCC general inventory QC table¹: each is a test with a pass condition, and the rule it tests belongs to the circular in the right-hand column. **Tolerances belong in the national QA/QC plan**, and this Circular strongly recommends that they be set there, taking account of regional conditions: the regional products and assessments a country verifies against, the regional fisheries body's assessment practice, and regional differences in ecosystem variability and data. The tolerance column gives indicative values only, for use until the plan sets its own; *plan* marks a check with no indicative value. The evidence each check leaves is listed in the evidence pack (Table 3.16.8).

ID	Check	Indicative tolerance	Rule owner
Identities			
AQ-ID1	Opening + additions – reductions (+ revaluation) = closing, per column. A residual is shown as a reappraisal, never absorbed	Zero, to rounding	TG-3.1 Section 3.1; Table 1b
AQ-ID2	Opening = previous closing; any restatement logged	Zero, or a logged restatement	TG-3.1
AQ-ID3	Sum of opening extents = sum of closing extents = accounting area, computed in an equal-area CRS	Zero, to rounding	TG-3.1 Table 2a; TG-2.12
AQ-ID4	Net reclassification = 0, and every reduction has a destination type or a recorded change to the accounting-area boundary	Zero	TG-3.1 Table 2b
AQ-ID5	Change-matrix margins = opening and closing extent; gross conversions come from the off-diagonals, never a net figure used as gross	Zero, to rounding	TG-3.1; TG-4.1
AQ-ID6	Totals = sum of parts. Memorandum, experimental, ABNJ and produced rows, and the stand-alone SEEA CF stock value, stay out of ecosystem totals	Zero	TG-3.1; TG-6.7
Units and recomputation			
AQ-UN1	Order of magnitude: ha against km ² , USD against USD thousand, one price base per table; the implied unit value of every monetary entry with a physical counterpart is checked	Ratio within 10 ^{±0.5}	Generic check (moves to TG-0.7)
AQ-UN2	Carbon unit stated on every row; 44/12 recorded; the price unit matches the quantity unit	Exact	Generic check (moves to TG-0.7)

ID	Check	Indicative tolerance	Rule owner
AQ-UN3	Catch in live-weight equivalent, from one conversion-factor source per species and form	Exact	TG-3.1 Step 4
AQ-UN4	Every figure quoted in text recomputed, and a sample of derived cells (at least 10% at Tier 2)	Exact at the printed precision	Generic check (moves to TG-0.7)
Routing			
AQ-RT1	Type changed: conversion. Condition lost in a discrete event: catastrophic loss. Gradual decline: degradation. Storm damage is an extent change only beyond the regrowth horizon	Rule	TG-3.1 Section 3.5.3
AQ-RT2	Revisions kept apart from genuine change, with the revision class logged (Table 3.16.3)	Rule	TG-3.1; TG-6.7
AQ-RT3	A mineral class move is a reclassification, not a discovery	Rule	TG-3.1 Section 3.4.2
AQ-RT4	Planting enters extent only after the year-3 survival check; a condition gain is enhancement	Rule	TG-6.2
Physical to monetary			
AQ-PM1	Each monetary volume entry = its physical entry × the stated unit value; no quantity valued in two rows	Zero, to rounding	TG-3.1 Section 3.3
AQ-PM2	Opening value per unit of stock agrees with the flow valuation, or the difference is explained	Plan	TG-3.1 Section 3.4.1
AQ-PM3	Depletion traces: renewable, max(0, extraction – sustainable yield at current biomass); non-renewable, extraction; valued at the mid-period price; a constant-price memorandum line	Zero, to rounding	TG-3.1; TG-6.7
AQ-PM4	Degradation traces to the index decline in Table 3c × the present value of the affected services. No index, no entry	Zero, to rounding	TG-3.1 Sections 3.5.2–3.5.3
AQ-PM5	Value change split into volume, reappraisal and revaluation; a constant-price view published; a physical decline beside a monetary gain explained	Rule	TG-3.1 Step 5
Valuation			
AQ-VA1	One resource-rent formula; normal return on produced capital deducted once; rent not negative; an unmanaged stock carries zero core value	Zero, to rounding	TG-3.1; TG-6.7
AQ-VA2	Condition adjustment applied once, at the service-flow step; the chain audited from flow to value	Equal to the index	TG-3.1 Section 3.5.3
AQ-VA3	Linear degradation shortcut only where the decline is at most 0.20, no thresholds are documented, and one service exceeds 70% of annual flow value	0.20; 70%	TG-3.1 Section 3.5.3
AQ-VA4	Horizon and trajectory stated; a perpetuity justified; a declining condition projected or the reason it is not recorded	Stated	TG-3.1 Section 3.5.3
AQ-VA5	Discount rate and source stated; sensitivity at three or more rates	Three or more rates	TG-1.9

ID	Check	Indicative tolerance	Rule owner
AQ-VA6	Exchange values only, so no social cost of carbon or willingness to pay in a cell; one carbon price per account, under the TG-6.2 rule	Exchange value only	TG-1.9; TG-6.2
AQ-VA7	Ecosystem contribution only; nursery and other intermediate services excluded; no licence fees or gross revenue	Rule	TG-3.2

¶4 Table 3.16.4: General QC checks for asset accounts. Indicative tolerances are for national plans to replace; those not taken from a rule owner are GOAP proposals.

¶5 Two of the rules these checks test are easier to follow as diagrams. Figure 3.16.2 is the routing rule behind AQ-RT1: which row a change enters, depending on what the event did. Figure 3.16.3 is the trace behind AQ-PM3, AQ-PM4 and AQ-VA2: how each monetary depletion and degradation entry is recomputed from a physical one, and the single point at which the condition index enters.

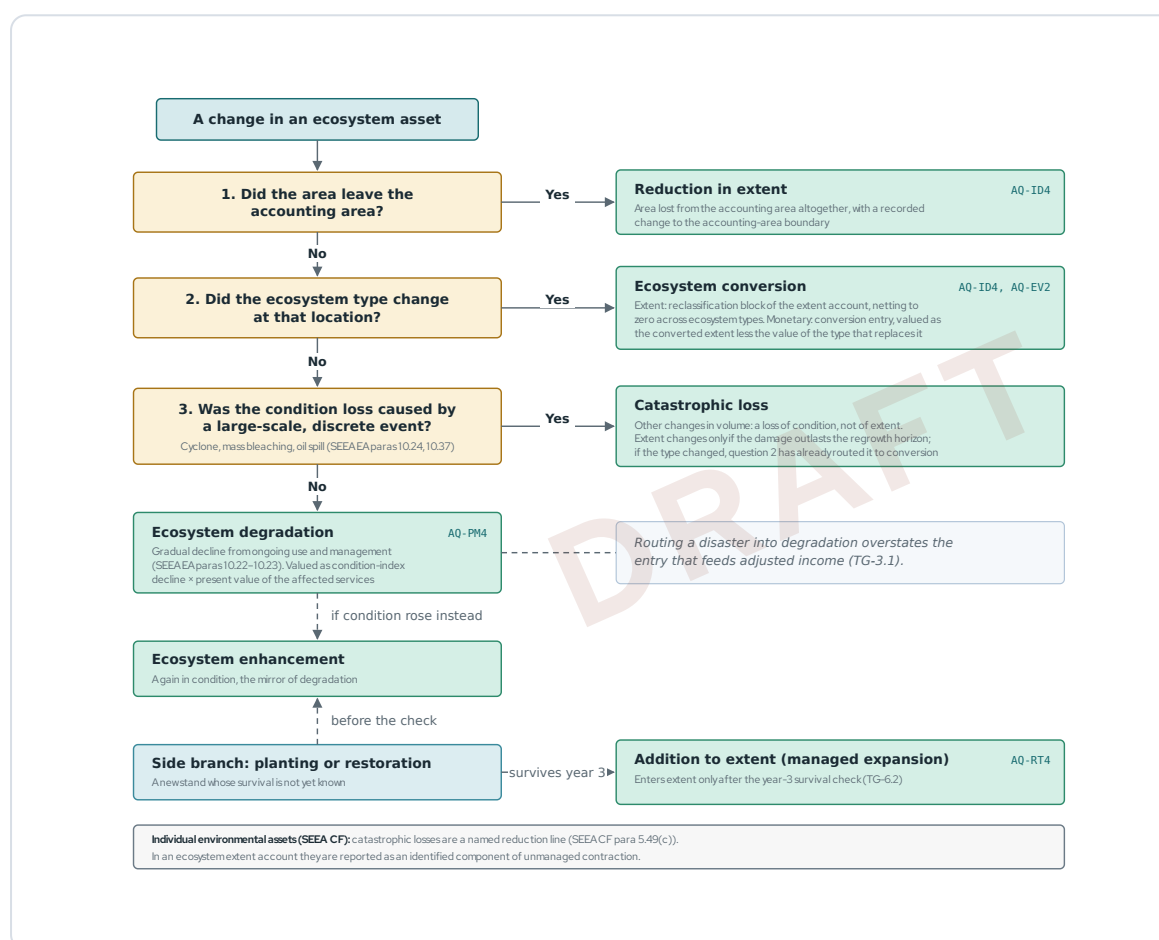


Figure 3.16.2 Where an event enters the account depends on what it did: moved the boundary, changed the type, or reduced condition suddenly or gradually. Ochre boxes are the questions, asked in order; green boxes are the account rows.

Source: TG-3.1 Sections 3.5.1 and 3.5.3; SEEA EA paras 4.15, 10.22–10.23, 10.24, 10.37.

Note: Storm damage changes extent only beyond the regrowth horizon; planting enters extent after the year-3 survival check (TG-6.2).

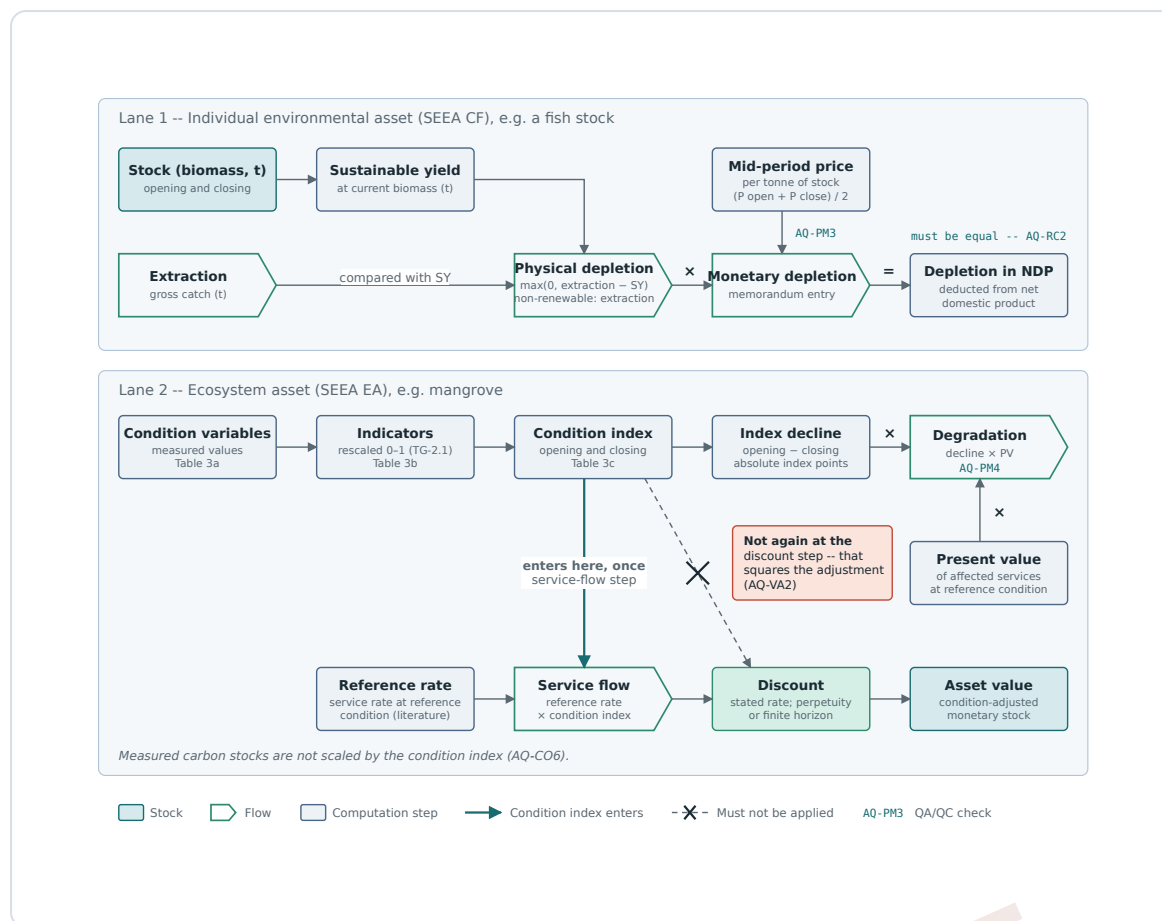


Figure 3.16.3 Every monetary depletion and degradation entry traces back to a physical entry, and the condition index enters the valuation once, at the service flow.

Source: TG-3.1 Sections 3.3 and 3.5.3; TG-2.1 Section 3.4.1.

Note: The linear degradation formula applies only within the three conditions of TG-3.1 Section 3.5.3 (AQ-VA3).

3.5 Asset-Type Acceptance Checks

¶1 An asset-type check is an acceptance test at the interface between the account and the method that feeds it, as TG-3.1 frames the requirements a stock assessment must meet. The account does not re-run the method. It tests whether what arrives is usable, and sends it back to the owning circular if not (Table 3.16.5).

ID	Acceptance check	Owner of the method
Aquatic resources		TG-6.7
AQ-FS1	Total biomass for opening and closing stock; SSB for B/B_{MSY} and sustainable yield; no switch of concept between periods	TG-6.7
AQ-FS2	Reported catch within the plan's tolerance of the assessment-implied catch (TG-6.7 Section 3.3, Step 6); the gap between the identity and the assessed closing stock shown as a reappraisal	TG-6.7
AQ-FS3	Gross catch includes discards by sector; IUU catch is recorded by the residence of the vessel (TG-4.10 Section 3.8.4); subsistence catch is estimated where it exceeds about 10% of harvest	TG-6.7; TG-4.10
AQ-FS4	CPUE alone does not close the account, and the metadata say so	TG-3.1
AQ-FS5	Assessment vintage recorded; a revised reference point is a reappraisal	TG-6.7
AQ-FS6	Cultivated and natural stocks kept apart	TG-3.9

ID	Acceptance check	Owner of the method
Mineral and energy resources		TG-3.10; TG-6.9
AQ-MN1	Classes A to C recorded; only Class A valued	TG-3.1 Section 3.4.2
AQ-MN2	Terminal (decommissioning) costs written off through consumption of fixed capital, so the rent is net of them; depletion kept apart from consumption of fixed capital	TG-3.10; TG-6.9
AQ-MN3	Installations (AN11), non-renewable resources (AN321) and renewable energy resources (AN322) never summed; ABNJ in satellite tables only	TG-3.10; TG-6.6
Water		TG-3.1 Section 3.4.3
AQ-WA1	Seawater outside the asset boundary; coastal aquifers only	TG-3.1
Extent		TG-4.1; TG-2.12
AQ-EX1	Probability sample of at least 50 points per class (30 for rare classes); accepted at overall accuracy of 80% and producer's and user's accuracy of 75%, otherwise "conditionally accepted" and graded C	TG-4.1 Sections 3.4.2–3.4.3
AQ-EX2	Area-adjusted estimate and its 95% confidence interval reported beside every mapped extent	TG-4.1 Section 3.4.3
AQ-EX3	Minimum mapping unit, dominance rule and equal-area CRS as TG-2.12 sets them	TG-2.12
AQ-EX4	Imagery within ±90 days of the period boundary (±45 days for high-seasonality types); an inter-layer lag over 6 months assessed, an area effect over 1% disclosed	TG-2.12
AQ-EX5	Deep seagrass recorded as a lower bound	TG-6.3
AQ-EX6	A confirmed zero recorded as 0; no data recorded as "..."	TG-0.7
Condition		TG-2.1; TG-4.8; TG-4.9
AQ-CO1	L, U, polarity and vintage fixed before data are collected, and held for the series. L and U come from the same ecosystem type and setting as the reporting unit; a naturally low-stature or low-cover setting is not treated as a degraded state of another	TG-2.1 Section 3.4.2
AQ-CO2	Rescaling by TG-2.1 Section 3.4.1 only; indicators in [0, 1]; V/ref not used unless a lower reference of zero is justified	TG-2.1
AQ-CO3	At least one variable per ECT class	TG-3.1 Section 3.5.2
AQ-CO4	Aggregation rule and weights stated; geometric-mean and one-out-all-out results reported as sensitivity	TG-2.1 Section 3.6
AQ-CO5	All three condition tables published; standard errors propagated to the index	TG-3.1 Section 3.5.2
AQ-CO6	Condition never used as a multiplier on measured carbon	TG-6.2; TG-6.3

ID	Acceptance check	Owner of the method
AQ-CO7	Each condition variable value lies within the plausibility range for its reporting unit and setting, or is flagged and its explanation logged. The range comes from the national reference-value register, and pooled national ranges are not used where values depend on setting	TG-4.8; TG-4.9
Monetary ecosystem		TG-3.1 Section 3.5.3; TG-2.4
AQ-EV1	AQ-VA2 to AQ-VA7 applied service by service	TG-3.1
AQ-EV2	Conversion value = converted extent × its unit value, less the value of the type that replaces it	TG-3.1 Section 3.5.3
AQ-EV3	Reappraisal kept apart from revaluation	TG-3.1 Section 3.5.3
AQ-EV4	Initial monetary releases labelled experimental	TG-3.1
Produced assets		TG-6.11; TG-3.1 Section 3.6
AQ-PR1	Never summed with ecosystem assets	TG-6.11
AQ-PR2	Decommissioning memorandum included	TG-3.1 Section 3.6
AQ-PR3	No protection value recorded on the produced side	TG-6.11

¶12 *Table 3.16.5: Asset-type acceptance checks. Each tests a rule set by the circular in the right-hand column; the extent thresholds are TG-4.1's.*

¶13 **Area estimates.** Where the area-adjusted estimate of AQ-EX2 (Olofsson et al. 2014)¹⁰ differs from the mapped area by more than the plan's tolerance, the account records the estimate and says so. This rule is proposed, for the owners of TG-4.1 and TG-2.12 to confirm.

3.6 Reconciliation and Verification

¶1 **Reconciliation** tests the asset account against the accounts compiled beside it. Each pair in Table 3.16.6 must agree within the plan's tolerance, or the difference is explained in the log. None of these pairs is new: each is required by the circular that owns the neighbouring account. What this Circular adds is the requirement to run all of them and record the result (Figure 3.16.4).

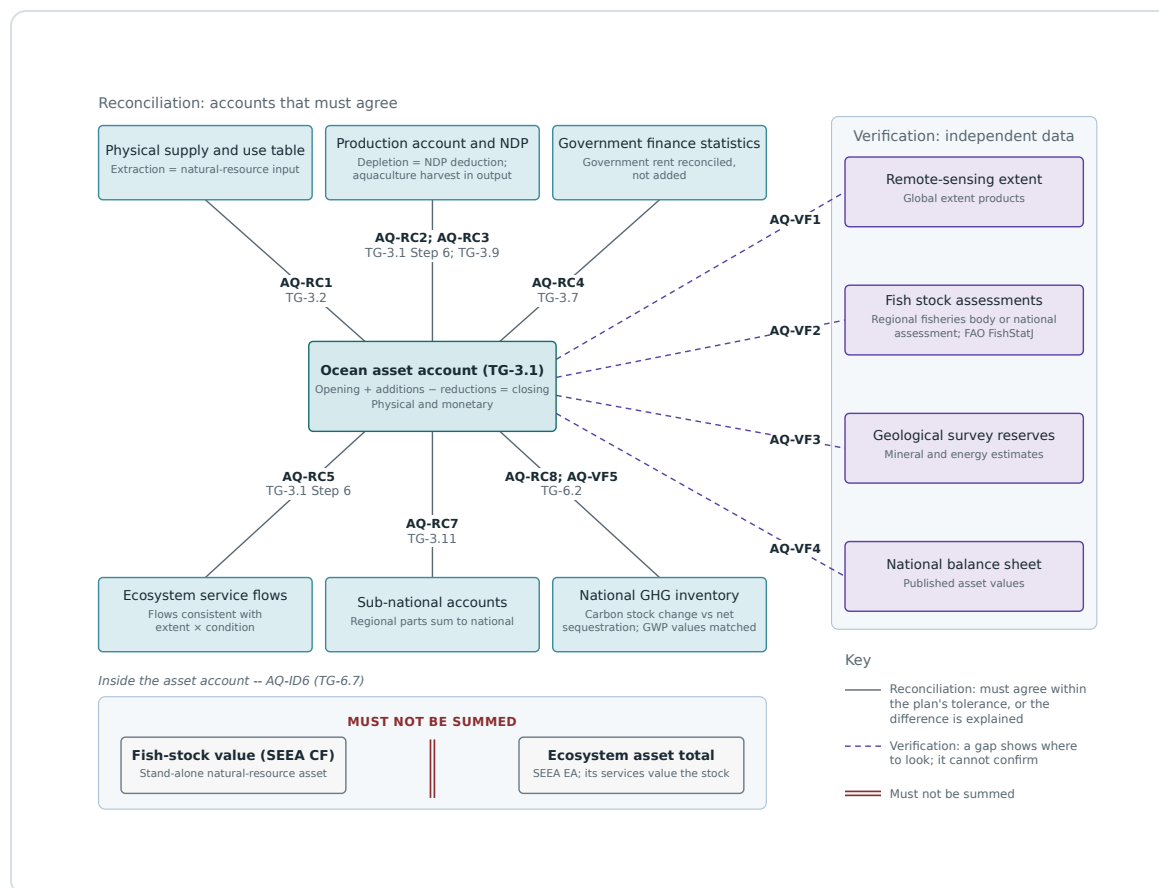


Figure 3.16.4 The asset account is reconciled with neighbouring accounts and verified against independent data; each spoke names its check and owning circular.

Source: TG-3.1 Step 6; TG-3.2; TG-3.7; TG-3.11; TG-6.2; IPCC (2006) Vol. 1, Ch. 6, Section 6.10; IMF DQAF element 3.4.

Note: Reconciliation pairs must agree within the tolerance in the QA/QC plan or be explained in the log.

ID	Asset-account cell	Must agree with	Owner
AQ-RC1	Extraction	Natural-resource input in the physical supply and use table	TG-3.2; TG-3.1 Step 6
AQ-RC2	Depletion	Depletion deducted in net domestic product	TG-3.1 Step 6
AQ-RC3	Aquaculture harvest	Harvest in the production account	TG-3.9
AQ-RC4	Total resource rent	Government rent receipts and government finance statistics, reconciled, not added	TG-3.7; TG-3.1
AQ-RC5	Service flows	Extent × condition capacity	TG-3.1 Step 6
AQ-RC6	Change-matrix margins	Opening and closing extent (run as AQ-ID5)	TG-3.1
AQ-RC7	Sub-national parts	National totals, with ratios rebuilt from levels	TG-3.11
AQ-RC8	Carbon stock change	Net sequestration, in sign and order of magnitude	TG-6.2; TG-6.3

¶2 Table 3.16.6: Reconciliation matrix.

¶3 **Verification** compares the account with data from outside it^{1, 5}. It cannot confirm a figure, because the comparator has its own error, but a large gap shows where to look. The checks are:

- ¶4 **AQ-VF1.** Extent against a global product; document the cause of a gap over 15% (TG-4.1 Section 3.3.5).
 - ¶5 **AQ-VF2.** Stock against the regional fisheries body's or the national assessment, and catch against FAO FishStatJ.
 - ¶6 **AQ-VF3.** Mineral and energy reserves against the geological survey.
 - ¶7 **AQ-VF4.** Monetary totals against the national balance sheet.
 - ¶8 **AQ-VF5.** Carbon stocks and flows against the national GHG inventory, with global warming potentials matched to the inventory's.
- ¶9 **Trend checks.** Each cycle is compared with the previous one, following IPCC practice¹. Implied unit prices and unit rents are compared across years, and any extent change beyond the national threshold in the plan is investigated.

3.7 Quality Flags for Asset Cells

¶1 TG-0.7 Section 3.6 defines one flag scheme. This Circular applies it to asset cells in two fields, so that a cell can say both how good it is and how it was obtained (Figure 3.16.5):

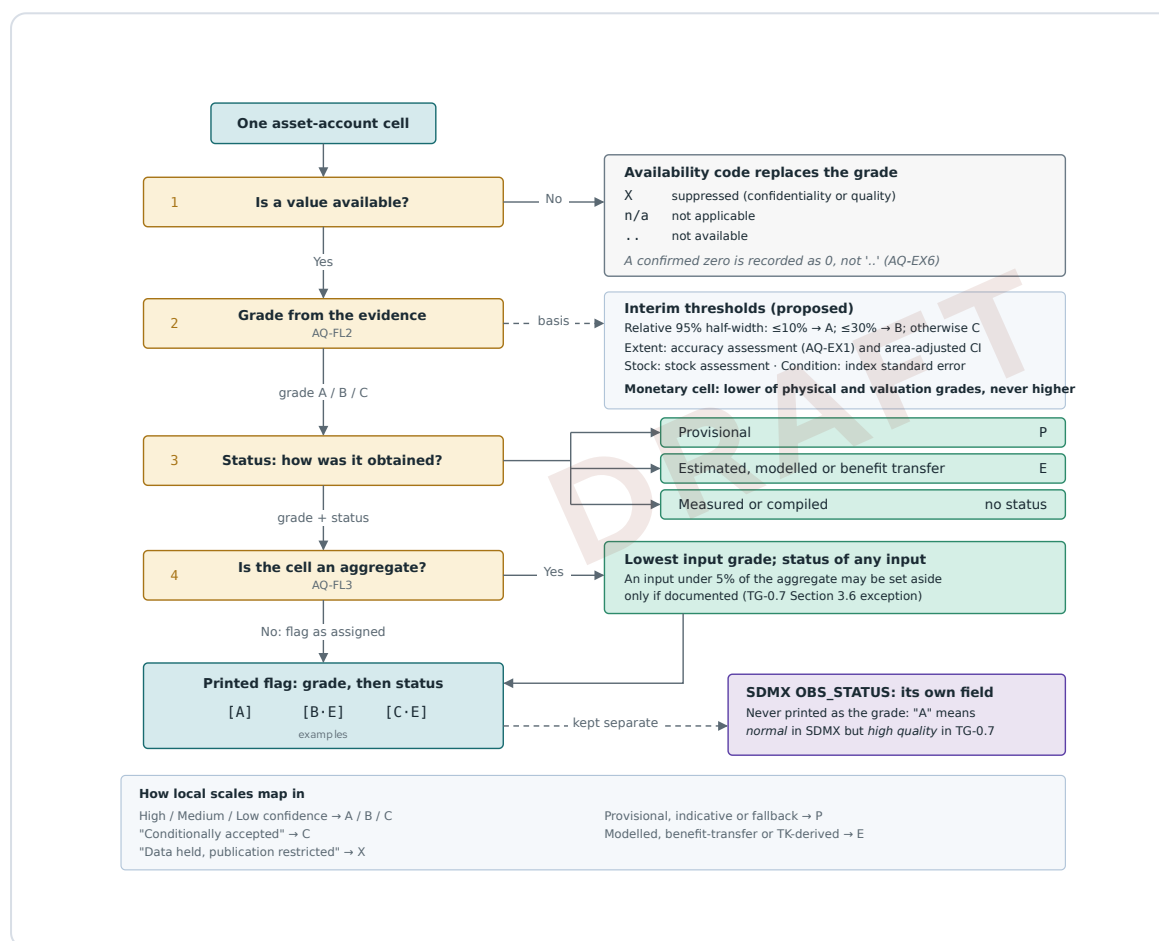


Figure 3.16.5 Each asset cell carries a grade from its evidence and a status from how it was obtained; availability codes replace the grade. Aggregates take the lowest input grade, and SDMX observation status stays in its own field.

Source: TG-0.7 Section 3.6 (flag scheme and lowest-flag rule); TG-3.16 Section 3.7 (AQ-FL1 to AQ-FL3).

Note: Grade thresholds are interim and proposed for consultation.

- ¶2 **AQ-FL1: two fields per cell.** A **grade** (A, B or C) and a **status** (P for provisional, E for estimated, or none). The availability codes X, n/a and "." replace the grade. An SDMX observation status, where reported, goes in a third field and is never printed as the grade ("A" means *normal* in

SDMX). In the tables of Section 3.8 the flag follows the value in brackets, grade first: [A], or [C·E] for a grade-C estimated value.

- ¶3 **AQ-FL2: what a grade rests on.** The grade basis is proposed for consultation, as follows. Extent takes its grade from AQ-EX1 and the width of the area-adjusted confidence interval. A stock takes its grade from the stock assessment, and condition from the standard error of the index. Where no standard error can be computed, which is common where condition variables come from published studies and non-probability surveys, the condition grade rests on the evidence behind each input instead: A for a full-text primary source that reports *n* and a labelled dispersion type; B for a full-text source without them, or a statistic the compiler computed from non-probability survey records; C for a value read from an abstract, from grey literature or digitised from a figure. A regional or global proxy takes status E. The index takes the lowest grade of its inputs under AQ-FL3. A monetary cell takes the lower of its physical grade and its valuation grade, and never a higher one. The interim thresholds, adopted as a proposal only pending decision on the flag scheme, are a relative 95% half-width of at most 10% for A and at most 30% for B, with C above that.
- ¶4 **AQ-FL3: propagation.** An aggregate takes the lowest grade of its inputs, and the status of any. A closing stock takes the lowest flag of its opening stock and its flows, and depletion takes the flag of the sustainable yield. The TG-0.7 exception, which lets an input under 5% of the aggregate be set aside, may be used only where it is documented; the worked example uses it twice and records both.
- ¶5 **AQ-FL4: tier direction.** Any tier cited in the account or its metadata states its scheme and direction (TG-0.7 Section 3.8), because some circulars use Tier 1 for the best data.

¶6 Local scales map onto the scheme. High, medium and low confidence become A, B and C. TG-4.1's "conditionally accepted" becomes C. Provisional, indicative and fallback values take status P, and modelled, benefit-transfer and TK-derived values take status E. "Data held but publication restricted" becomes X.

3.8 Worked Example: A Coastal Asset Account with Seeded Errors

¶1 This example is synthetic, and every number in it comes from one script run on one set of inputs. It is independent of the TG-3.1 worked example. An accounting area of 1,200 km² holds five ecosystem types, one demersal fish stock and a mangrove condition account; the period is one calendar year, and money is in USD thousand at current prices. The submitted accounts contain nine deliberate errors, E1 to E9, of kinds common in compiled accounts (Table 3.16.7).

Error	What the compiler did	Table	Caught by
E1	Booked 0.4 km ² of mangrove converted to ponds as a reduction, with no destination	WE-2	AQ-ID3, AQ-ID4, AQ-ID5
E2	Booked seagrass loss of 0.9 km ² and gain of 0.3 km ² as one net conversion of 0.6 km ²	WE-2	AQ-ID5
E3	Applied the mangrove condition index to the flow and again to the value	WE-6a	AQ-VA2, AQ-PM4
E4	Priced mangrove and seagrass carbon at a social cost of carbon	WE-1, WE-6a	AQ-VA6, AQ-VA3
E5	Entered the seagrass conversion ten times too large	WE-6a	AQ-UN1, AQ-EV2
E6	Added the stand-alone SEEA CF fish-stock value to the ecosystem total	WE-6c	AQ-ID6
E7	Valued the catastrophic fish loss inside the catch row and again on its own	WE-6b	AQ-PM1
E8	Computed stock status on total biomass instead of SSB	WE-5	AQ-FS1

Error	What the compiler did	Table	Caught by
E9	Quoted the conversion as a share of the mangrove type, not of the accounting area	WE-6d	AQ-UN4

¶12 *Table 3.16.7: Seeded errors and the checks that catch them.*

¶13 Two things in Table 3.16.7 are worth noticing. First, AQ-ID1 catches none of the errors: every submitted column balances. Second, several errors trip more than one check. E4 is the clearest case: a welfare price for carbon breaks the exchange-value rule, and by inflating carbon's share of the mangrove's annual flow value it also takes the asset outside the conditions under which the linear degradation shortcut may be used.

¶14 Three tables are printed here: the submitted monetary ecosystem account, which holds three of the errors; the QC log; and the same account corrected and flagged. **All 22 tables of the example** – the parameter register, the extent, change-matrix, condition and fish-stock accounts, every submitted and corrected table, the reconciliation and the uncertainty results – are in a companion page, with the QC log also as [CSV](#).

¶15  **As submitted – contains deliberate errors**

¶16 Table WE-6a is shown as a compiler submitted it. Do not copy it as a model.

¶17 **Table WE-6a: Monetary ecosystem asset account, as submitted (USD thousand)**

Accounting entry	Mangrove	Seagrass	Aquaculture ponds	Total
Opening value	132,859	22,587	0	155,446
Ecosystem enhancement	0	0	0	0
Ecosystem degradation	-5,066	..	..	-5,066
Ecosystem conversions (additions)	0	271	0	271
Ecosystem conversions (reductions)	-886	-8,131	0	-9,017
Catastrophic losses	0	0	0	0
Reappraisals	0	0	0	0
Revaluation	0	0	0	0
Closing value	126,907	14,727	0	141,634

¶18 *Subtidal sediment and Shelf waters: not valued (".."), so not shown. Aquaculture ponds: a confirmed zero, not a gap.*

¶19 *Table WE-6a: Monetary ecosystem asset account as submitted, containing errors E3, E4 and E5. Structure after TG-3.1 Table 4.*

¶10 The QC log is the record the reviewer reads (Table WE-7). One line is written per finding, naming the check, the cell and what was found; the fix is recorded against the same line.

¶11 **Table WE-7: QC log for the submitted set**

Check	Cell	Finding
AQ-ID3	WE-2 total closing	Closing total 1,199.6 km ² against an EAA of 1,200.0 km ²
AQ-ID4	WE-2 mangrove reductions	0.4 km ² leaves mangrove with no destination type and no change to the EAA boundary
AQ-ID5	WE-2 mangrove conversions to	Account records 0.0 km ² ; matrix off-diagonals give 0.4 km ²
AQ-ID5	WE-2 seagrass conversions to	Account records 0.6 km ² ; matrix off-diagonals give 0.9 km ²

Check	Cell	Finding
AQ-ID5	WE-2 seagrass conversions from	Account records 0.0 km ² ; matrix off-diagonals give 0.3 km ²
AQ-ID5	WE-3 ponds column	Column margin 15.4 km ² against closing extent 15.0 km ²
AQ-ID5	WE-2 ponds conversions from	Account records 0.0 km ² ; matrix off-diagonals give 0.4 km ²
AQ-ID5	WE-2 sediment conversions to	Account records 0.0 km ² ; matrix off-diagonals give 0.3 km ²
AQ-ID5	WE-2 sediment conversions from	Account records 0.6 km ² ; matrix off-diagonals give 0.9 km ²
AQ-ID6	WE-6c total opening	Total exceeds the ecosystem types by 49,023, the stand-alone SEEA CF fish-stock value
AQ-ID6	WE-6c total closing	Total exceeds the ecosystem types by 50,839, the stand-alone SEEA CF fish-stock value
AQ-UN1	WE-6a seagrass conversions (reductions)	Implied 9,035 per km ² against an opening unit value of 903 per km ² : about 10 times
AQ-UN4	text N1	Text says 0.667; recomputed 0.033
AQ-PM1	WE-6b catch	Entry values 7,500 t; the physical account records 7,000 t
AQ-PM4	WE-6a mangrove degradation	Entry -5,066; index decline × PV of affected services gives -3,579
AQ-VA2	WE-6a mangrove opening	Value implies a condition factor of 0.533; the index is 0.730 (the index squared)
AQ-VA2	WE-6a mangrove closing	Value implies a condition factor of 0.470; the index is 0.685 (the index squared)
AQ-VA3	WE-6a mangrove degradation	Largest service (carbon) is 60% of annual flow value, not over 70%
AQ-VA6	WE-1 carbon price	Carbon priced on an SCC basis (USD 185 per tCO _{2e}); account cells hold exchange values
AQ-FS1	WE-5 B/BMSY	Ratio 1.91 computed on total biomass; on SSB it is 0.78
AQ-EV2	WE-6a seagrass conversions (reductions)	Entry -8,131; 0.9 km ² × 903.5 gives -813

¶12 *Table WE-7: QC log. Thirteen checks fail; AQ-ID1 is not among them.*

¶13 Each correction follows the rule its check names; here the condition index enters once, carbon takes the exchange-value price, and the seagrass entry is re-derived from its unit value.

¶14 **Table WE-8c: Monetary ecosystem asset account, corrected and flagged (USD thousand)**

Accounting entry	Mangrove	Seagrass	Aquaculture ponds	Total
Opening value	73,628 [C·E]	14,529 [C·E]	0 [A]	88,157 [C·E]
Ecosystem enhancement	0	0	0	0
Ecosystem degradation	-3,579	..	..	-3,579
Ecosystem conversions (additions)	0	174	0	174
Ecosystem conversions (reductions)	-491	-523	0	-1,014
Catastrophic losses	0	0	0	0
Reappraisals	0	0	0	0
Revaluation	0	0	0	0
Closing value	69,558 [C·E]	14,180 [C·E]	0 [A]	83,738 [C·E]

¶15 *Subtidal sediment and Shelf waters: not valued (".."), so not shown. Aquaculture ponds: a confirmed zero, not a gap.*

¶16 *Table WE-8c: Monetary ecosystem asset account, corrected. Every valued cell except the confirmed zero for ponds is C-E, because the valuation ranges are wide (companion Table WE-10b).*

¶17 **What the example shows.** An account can be internally consistent and still wrong in six ways. It can be incomplete (E1); recorded net where gross is required (E2); in breach of a valuation rule (E3, E4); carrying an arithmetic slip (E5, E9); letting a total or a row take in an item that belongs elsewhere (E6, E7); or computing a derived figure on the wrong concept (E8). Each is caught by a check that recomputes from evidence outside the row being checked: the change matrix, the parameter register, the unit value, the physical account, or the stock assessment.

3.9 Uncertainty Assessment

¶1 TG-0.7 Section 3.4 names the four categories of uncertainty from SEEA EA paras 2.90–2.94, with their usual sources in ocean accounts², and this Circular does not repeat them. For asset accounts three physical sources dominate, and each has its method elsewhere: the area confidence interval from the accuracy assessment (AQ-EX2), the biomass and sustainable-yield intervals from the stock assessment (TG-6.7 Section 3.6), and the standard error of the condition index (AQ-CO5). Valuation and future-price uncertainty are carried by the discount-rate grid (AQ-VA5) and by the range reported with every value.

¶2 **Method.** Uncertainty is quantified up a ladder, going as far as the data allow: a qualitative statement; an analytic, first-order combination in the manner of the GUM¹¹; Monte Carlo propagation with at least 1,000 draws¹²; and a Bayesian treatment where priors are defensible. Intervals are reported at 95%. For an asset valued as the present value of its flows, the analytic step is

¶3

$$V = \sum_{t=1}^T \frac{Q_t p_t}{(1+r)^t}, \quad \left(\frac{u_V}{V}\right)^2 \approx \left(\frac{u_Q}{Q}\right)^2 + \left(\frac{u_p}{p}\right)^2$$

¶4 where Q_t is the quantity, p_t the unit value, and u a standard uncertainty. The quadrature form assumes the quantity and the price are independent. Where they are not, as when a sustainable yield and a unit rent both depend on the same biomass, Monte Carlo over rent, sustainable yield, discount rate and horizon replaces it.

¶5 **Reporting.** Every monetary asset value is published with its range. The discount-rate grid (AQ-VA5) and the aggregation-rule sensitivity (AQ-CO4) go beside the account, not in an annex a user may not open.

¶6 **Modelled flows.** Where a service flow or a stock comes from a model, it is validated as TG-4.11 Section 3.3 sets out. Until it is, it is flagged E (TG-4.5 Section 3.3.3). A biophysical model also conserves mass and area, the check the IPCC 2019 Refinement adds in Section 6.12¹³.

3.10 Review, Documentation and Release

¶1 **AQ-RV1: review.** A reviewer not involved in compilation reviews the evidence pack, recomputes a sample of cells and every headline figure, and logs each finding as closed or accepted¹. Independent review is recommended, not a condition of release. For an asset account the reviewer should include a subject specialist for each part compiled: a stock-assessment scientist for the stock, a remote-sensing accuracy specialist for extent, and an environmental economist for valuation. Tier 3 makes this the standard (Section 3.2).

¶2 **AQ-RV2: documentation.** The four documentation categories of TG-0.7 Section 3.5 are completed for the account². Beyond these, an asset account records the biomass concept, the assessment vintage and the valuation method; every other setting is in the parameter register (Section 3.3). Where an SDG indicator is derived from the account, the validation and quality fields of its metadata (4.d and 4.i to 4.k) are completed from the same record¹⁴.

¶3 **AQ-RV3: archive.** Inputs, version-controlled code, the parameter register, the QC log and the outputs are archived together, sufficient for anyone to reproduce every published cell¹, ¹⁵.

¶4 **AQ-RV4: release gate.** The account is released when four conditions hold:

- ¶5 no blocking issue is open in the issue register;
- ¶6 no P-flagged value appears in headline text;
- ¶7 the statistical owner has signed off;
- ¶8 traditional knowledge is released only with the community authority's written approval.

¶9 Initial monetary releases are labelled experimental (AQ-EV4).

¶10 **The evidence pack.** Every account keeps a generic evidence pack: the scope and boundary statement (accounting area, period, boundaries, residence or territory, BSU level); the QA/QC plan with its tolerance register; the source register (every source, its owner, licence, date, method and coverage); and the archive manifest. Table 3.16.8 lists what an asset account adds; each item is produced during compilation, and none is written for the review.

Item	Contents
Balanced workbook	An identity column on every table; opening = previous closing
Depletion and degradation trace sheet	AQ-PM3 and AQ-PM4, cell by cell
Constant-price view	AQ-PM5
Valuation parameter register	Every parameter with its source, vintage and owner
Accuracy report	AQ-EX1 and AQ-EX2
Stock-assessment acceptance note	AQ-FS1 to AQ-FS6
Reconciliation and verification log	Table 3.16.6
Flagged table set	A grade and status on every cell; the lowest-flag derivation for aggregates
Uncertainty annex	Method, ranges and sensitivity grids
Revision and break log	Revision class, back-casts, breaks
Review record	Reviewer, sample recomputed, findings, dispositions

¶11 Table 3.16.8: What an asset account adds to the generic evidence pack.

3.11 Limitations

¶1 Four limits apply to everything above. First, a future SEEA quality framework may supersede parts of this Circular (Section 3.1). Second, the tolerances here are indicative. Several are GOAP proposals, not SEEA rules: the 0.20 decline and 70% share of the linear shortcut, the 80% and 75% accuracy thresholds, and the interim grade thresholds. Third, the monetary ecosystem checks inherit the status the UN Statistical Commission gave SEEA EA chapters 8 to 11: internationally recognised statistical principles and recommendations, and not a full statistical standard¹⁶. Fourth, coherence is not validity. An account can pass every check here and still rest on an ecological model that is wrong, and only verification against independent observation, repeated over cycles, tests that.

4. Acknowledgements

¶1 **Authors:** [To be confirmed]

¶2 **Reviewers:** [To be confirmed]

¶3 The structure of this Circular draws on the IPCC inventory guidelines' treatment of quality assurance, quality control and verification, on the UN National Quality Assurance Frameworks Manual, and on the IMF Data Quality Assessment Framework.

5. References

1. ¶1 IPCC (2006). *2006 IPCC Guidelines for National Greenhouse Gas Inventories*, Volume 1, Chapter 6: Quality Assurance/Quality Control and Verification. Box 6.1 (definitions), Section 6.4 (roles, including the QA/QC coordinator), Section 6.5 (QA/QC plan and data-quality objectives), Section 6.6 and Table 6.1 (general QC procedures, including trend checks and sampling across years), Section 6.8 (QA by reviewers not involved in compilation), Section 6.10 (verification), Section 6.11.1 (internal documentation and archiving). IGES, Hayama. https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/1_Volume1/V1_6_Ch6_QA_QC.pdf (https://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/1_Volume1/V1_6_Ch6_QA_QC.pdf)
2. ¶2 United Nations et al. (2024). *System of Environmental-Economic Accounting – Ecosystem Accounting*, Statistical Papers Series F No. 124. Paras 2.86–2.89 (data quality; para 2.89 refers to the IMF DQAF), 2.90–2.94 (four categories of uncertainty), 2.95 (documentation of scope, definitions, methods and assumptions); the Section D overview, which suggests labelling initial monetary releases as experimental; and the research and development agenda, which lists data quality assessment frameworks as future work. Paragraph numbers are the same in the 2021 white-cover edition.
3. ¶3 United Nations et al. (2014). *System of Environmental-Economic Accounting 2012 – Central Framework*. Paras 1.54 and 6.7 (data confrontation), 6.64–6.70 (time series and revisions; para 6.68, revisions as standard practice), 6.86 (volume measures as data confrontation).
4. ¶4 United Nations (2019). *United Nations National Quality Assurance Frameworks Manual for Official Statistics*, Studies in Methods Series M No. 100. Requirement 15.1: "Source data, integrated data, intermediate results and statistical outputs are regularly assessed and validated." Welcomed by the UN Statistical Commission, decision 50/106.
5. ¶5 International Monetary Fund. *Data Quality Assessment Framework: Generic Framework*. Element 3.4, assessment and validation of intermediate data and statistical outputs (indicators 3.4.1–3.4.3). https://dsbb.imf.org/content/pdfs/dqrs_Genframework.pdf (https://dsbb.imf.org/content/pdfs/dqrs_Genframework.pdf)
6. ¶6 UNECE (2025). *Generic Statistical Business Process Model*, version 5.2. Sub-processes 5.3 (review and validate) and 6.2 (validate outputs).
7. ¶7 SEEA EA (2024), para 10.40: documenting all revisions to the accounts is strongly recommended for data quality assessment.
8. ¶8 SEEA EA (2024), para 4.17: no distinct entry is recorded for revisions to extent; the entries for opening and closing extent and for additions and reductions are altered, and it may be appropriate to show the size of the revision for analysis and dissemination.
9. ¶9 SEEA EA (2024), para 10.38: reappraisals are recorded when updated information permits a reassessment of the expected condition of ecosystem assets or the future demand for their services.
10. ¶10 Olofsson, P., Foody, G. M., Herold, M., Stehman, S. V., Woodcock, C. E. and Wulder, M. A. (2014). Good practices for estimating area and assessing accuracy of land change. *Remote Sensing of Environment* 148, 42–57. <https://doi.org/10.1016/j.rse.2014.02.015> (<https://doi.org/10.1016/j.rse.2014.02.015>)
11. ¶11 JCGM (2008). *Evaluation of measurement data – Guide to the expression of uncertainty in measurement* (GUM), JCGM 100:2008.
12. ¶12 JCGM (2008). *Evaluation of measurement data – Supplement 1 to the GUM: Propagation of distributions using a Monte Carlo method*, JCGM 101:2008.
13. ¶13 IPCC (2019). *2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories*, Volume 1, Chapter 6, Section 6.12: Use and reporting of models, including conservation of mass and land area.
14. ¶14 United Nations Statistics Division. SDG indicator metadata template, fields 4.d (validation) and 4.i–4.k (quality management, quality assurance, quality assessment). See, for example, the metadata for indicator 14.5.1.
15. ¶15 United Nations (2022). *Guidelines on Biophysical Modelling for Ecosystem Accounting*, Chapter 7: Data quality for biophysical modelling. Paras 359–369 (accuracy, reliability and model validation), 374–375 (provenance and version control).
16. ¶16 United Nations Statistical Commission, decision 52/108 (March 2021), as recorded in the Preface to SEEA EA (2024): chapters 8 to 11 "describe internationally recognized statistical principles and recommendations for the valuation of ecosystem services and assets". The Commission adopted chapters 1 to 7 as an international statistical standard.

DRAFT