Carbon Removal
Standards Initiative

Methodology v1 - last updated 6 Aug 2024

Introducing the CRSI Database

The CRSI Quantification Resources Database was built to collect and organize information on the quantification of carbon fluxes in the Earth system, with a specific focus on durable carbon removal. The content of this database can be used by policymakers, carbon removal suppliers, voluntary buyers, and the public to inform assessment of the net carbon impact of removal processes.

These quantification resources include descriptions of procedures, instruments, measurement techniques, models, data, calculations, and/or estimation methods that can be used to determine the total number of tonnes of carbon that move between carbon reservoirs over a certain period of time. For any carbon removal process, there is a collection of relevant fluxes that cover the movement of the carbon from the point that it is removed from the atmosphere to the point that it is stored in a reservoir outside of the atmosphere. If all of the relevant fluxes are quantified, net negativity can be calculated (in tonnes CO_2e).

For more information on the scope and purpose of this database, see our Blog Post.

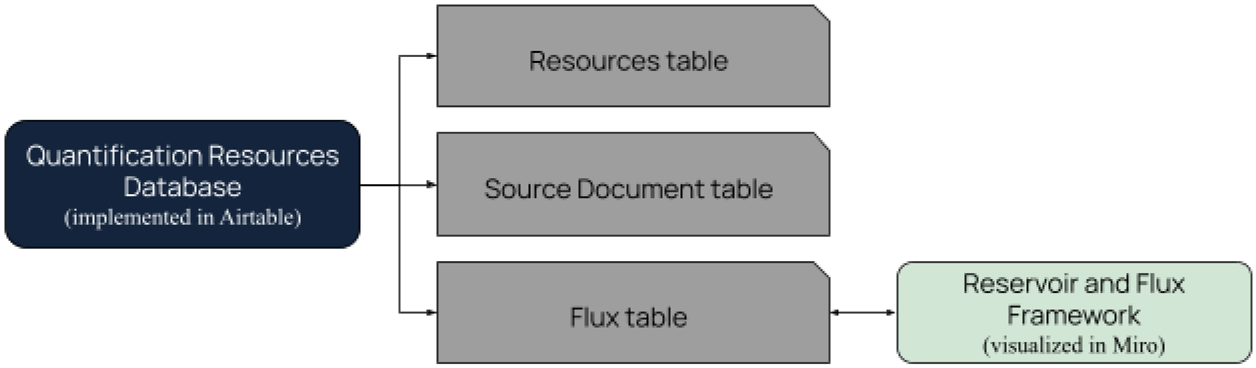
Structure of the Database

The Database consists of three tables.

- The primary table is the Quantification Resources table, which contains the quantification resources we've identified.
- The items in the Quantification Resources table originate from source documents, which are contained within the Source Document table. Each quantification resource is uniquely identified by a source document and one or more fluxes described by the resource.
- A complete list of fluxes are contained within the Flux table.

Each of these tables are described in further detail below. Definitions of all the terms used in the Quantification Resources Database can be found in the Glossary.

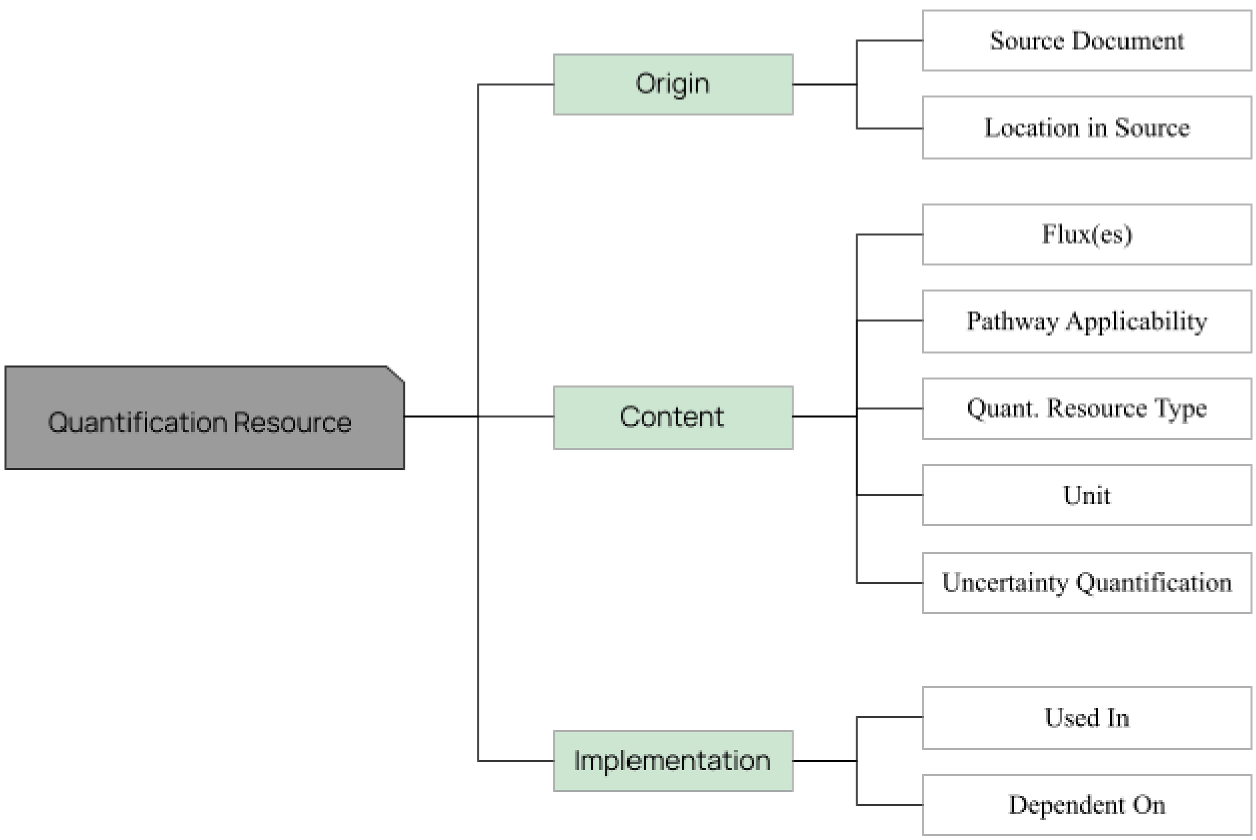
A brief explanation of how to navigate the Quantification Resources Database in Airtable can be found here.



Quantification Resources table

Each entry in this table represents an individual quantification resource. These resources are pulled from source documents. Each quantification resource links to the relevant source document in the Source Document table.

Each quantification resource entry contains information that can be used to understand the origin, content, and implementation of that resource.



Origin

The Quantification Resources table includes information about the origin of that resource, so you can trace back the source.

1. *Source Document* - Each quantification resource is contained within a source document, which is tagged in the "Source Document" column. You can learn more about this source document from the corresponding entry in the Source Document table.
2. *Location in Source* - Each quantification resource is a subset of the text within a source document; we've provided the section number and title in the "Location in Source Document" column so you can refer to the proper location within the source document.

Content

The Quantification Resources table also includes information about the content of that resource, so it can be applied to carbon removal calculations.

1. *Flux(es)* - We've mapped each quantification resource to one or more carbon fluxes. You can learn more about these fluxes from the corresponding entries in the Flux table.
2. *Pathway(s)* - The fluxes associated with a given quantification resource typically apply to one or more carbon removal pathways. These pathways are tagged in the "Pathway Applicability" column.
3. *Resource Type* - For searchability, we organize quantification resources by type, including: direct C measurement, proxy for C measurement, assumption, model, and calculation.
4. *Units* - We also include the units associated with a quantification resource (e.g. tonnes of CO_2 or tonnes of CO_2e).
5. *Uncertainty* - Lastly, we've included any discussion of uncertainty within the quantification resource.

Implementation

We've included information that can help users understand how a given quantification resource is implemented in existing carbon removal processes and may be implemented in future work.

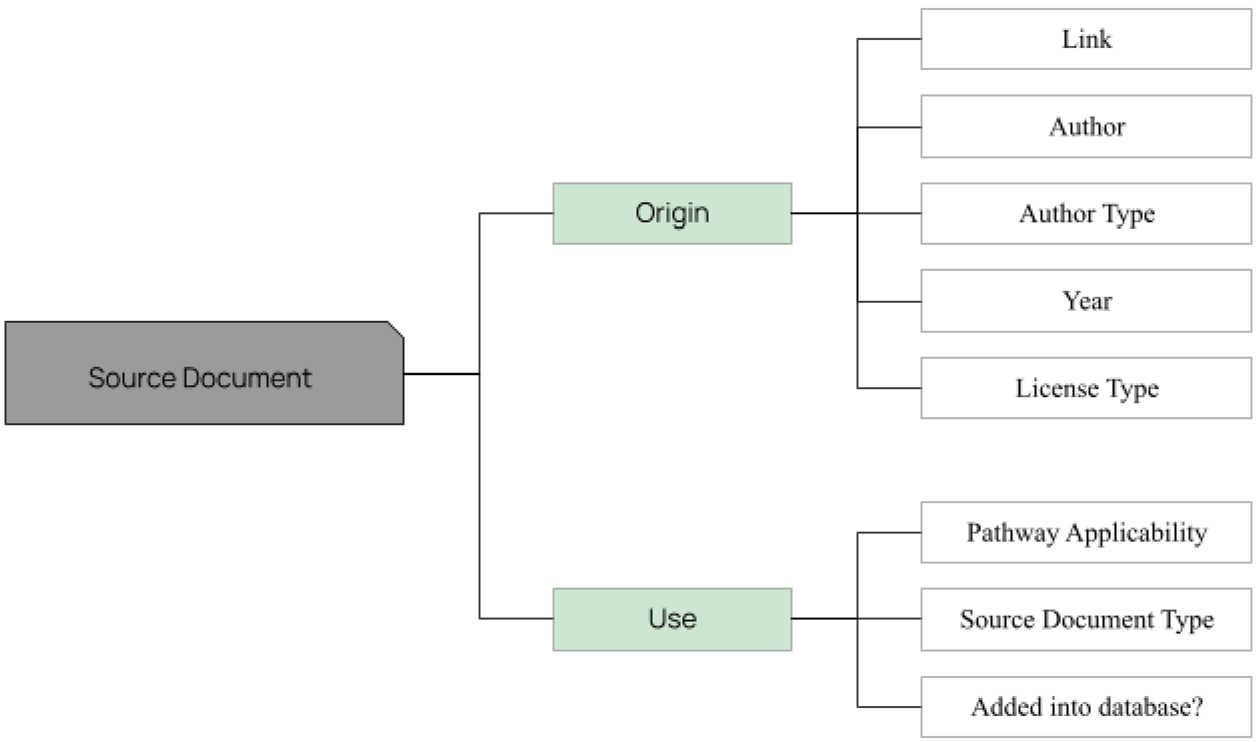
1. *Used In* - In some cases, a quantification resource will be cited in source documents other than the one it is contained within. In these cases, that source document is tagged in the "Used In (source document)" column.
2. *Dependent On* - In other cases, a quantification resource will cite another source document. In these cases, that source document is tagged in the "Dependent On (source document)" column.

Through these interdependencies, the database can be used to identify patterns within the carbon removal quantification ecosystem. For example, the EPA regulates the discharge of materials into waterways under the Clean Water Act. Many quantification resources related to the addition of alkalinity to waterways reference EPA guidance.

Source Documents table

Each entry in this table represents a unique website, database, or document, which contains one or more quantification resources. Examples of source documents include protocols (also referred to as methodologies) that are developed by carbon removal suppliers and/or credit issuers (also referred to as registries).

Each source document entry contains information on the document's origin and use.



Origin

For each source document we include information to enable easier searching and sorting.

1. *Link* - A link to the full source.
2. *Author* - The list of document author(s).
3. *Author Type* - The author type or type(s), e.g. academic, credit issuer, government, etc.
4. *Year* - Year of publication.
5. *License Type* - The license type, which indicates any intellectual property restrictions associated with the document (e.g. Creative Commons licenses). Users can use this

information to better understand who can use the information within these source documents, and how.

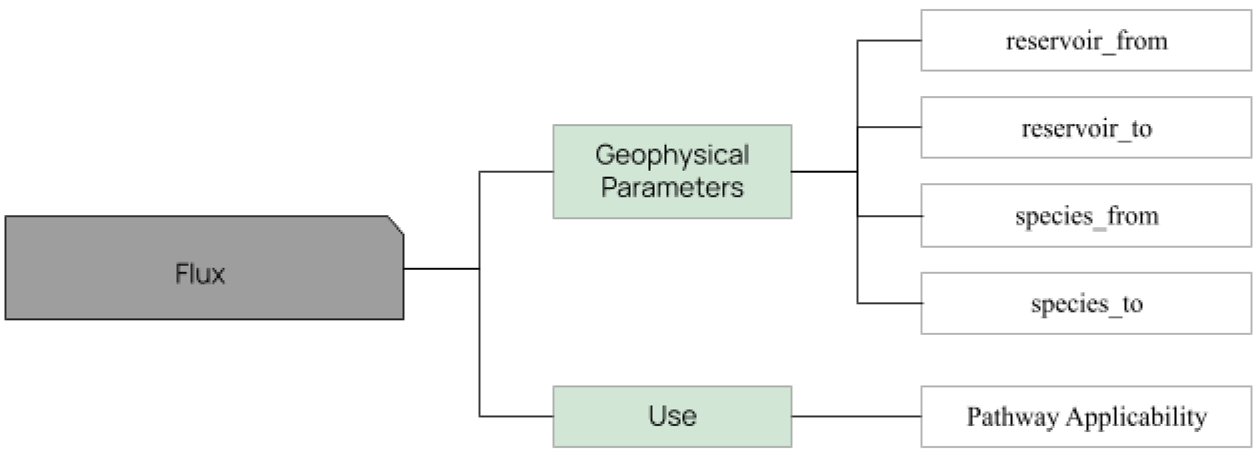
Use

For each source document, we include information about its use, so you can better understand how these source documents are currently being used, and how they can be used in future work.

1. *Pathway Applicability* - The relevant carbon removal pathway(s) associated with each of the source documents.
2. *Source Document Type* - The source document type, e.g. database, tool, protocol, etc.
3. *Added into database?* - Indicates whether the source document has been ingested into the Quantification Resources table.

A full list of author types, license types, pathways, and source document types, with their definitions, can be found in the Glossary.

Flux table



Each entry in this table represents an individual flux within or between reservoirs, where each flux corresponds to an arrow in the Carbon Reservoir and Flux Framework. To learn more about how we define and use fluxes, see our Carbon Reservoir and Flux Framework in Miro.

Geophysical Parameters

Each flux is uniquely identified by the combination of geophysical parameters:

- the reservoir of origin (*reservoir_from*),
- the reservoir that receives the transported carbon (*reservoir_to*),
- the chemical species of carbon at the origin (*species_from*), and
- the species of carbon after transport or chemical transformation (*species_to*).

We've adopted the convention that each flux will either represent a change of carbon species within a reservoir, or the movement of a specific carbon species between reservoirs. Thus, each flux will either have the same "reservoir_from"/"reservoir_to" or the same "species_from"/"species_to."

For example, "mixed layer carbonate precipitation" refers to the transformation of dissolved inorganic carbon to carbonate minerals in the mixed layer. The reservoir stays the same ("ocean - mixed layer") and the species changes. Similarly, "oceanic downwelling of DIC" refers to the transfer of dissolved inorganic between the ocean mixed layer and deep ocean. The species (DIC) stays the same and the reservoir changes.

Not all possible combinations of reservoirs and species are represented in the Flux table or the Reservoir and Flux Framework. Based on expert feedback, academic literature, and our judgment, we include only those fluxes that we expect to meaningfully impact net carbon removal calculations.

Use

Each flux is associated with one or more CDR pathways, indicated in the Pathway Applicability column, in the Flux table.

Note that a quantification resource can represent one, multiple, or all parts of a given equation or series of equations that are required to quantify a flux in its entirety. It is also possible for a quantification resource to quantify collections of multiple fluxes in their entirety; global and regional ocean models are good examples of this.

How the Database was built

To build the database, we started with an initial list of source documents. The source document discovery process involved a series of steps.

First, we referenced an initial list of ~110 source documents collected by CarbonPlan. That list was created in the context of the DOE-funded project to advance CDR measurement, reporting, and verification.

Next, we considered carbon removal protocols posted by credit issuers, independent protocols posted by carbon removal suppliers, and documents provided by carbon removal buyers. We also actively monitored academic publications and CDR news, and filled gaps with databases and tools posted by governments and other entities.

Then, we reviewed each source document to identify any embedded quantification resources that could be mapped to one or more fluxes within the Carbon Reservoir and Flux Framework. These were added to the Quantification Resources table.

If, through the process of entering a source document's resource(s) into the Quantification Resources table, we found that a given quantification resource relies on a source document that was not already represented in our Source Document table, we added it. All new source documents are then split into its quantification resource(s) and mapped to the appropriate fluxes.

Through this iterative process, the Database now stands at >280 source documents, >450 quantification resources, and >150 fluxes.

Looking forward

In building version 1 of the Database, we prioritized ingestion of a large volume of existing documents, breaking them down into quantifiable fluxes or combinations of fluxes.

In the coming months, we will work to bring the pieces back together, building more sophisticated tools for pathway-level analysis.

We're interested in questions like:

- For a given carbon removal pathway, which fluxes are required to calculate net removal?
- How many combinations of quantification resources exist for an end-to-end pathway?
- How do those resources assess uncertainty individually and in combination?
- What are the cost and practicality trade-offs of implementing different quantification methods?
- Where are the gaps, and who is best placed to fill those gaps while building consensus and rigor in the CDR industry?

We're not the only ones asking these deep technical questions. We're excited to incorporate our work into ongoing efforts, in and outside of government, to increase rigor and transparency in CDR quantification.

Please note that the Database is a living document. We will regularly add new resources and iterate on the structure and logic of the Reservoir and Flux Framework. Users should expect continuous updates to the Quantification Resources table and Source Documents table. Users should also expect periodic updates to the Flux table and Framework. Major updates will be recorded in this methodology document.

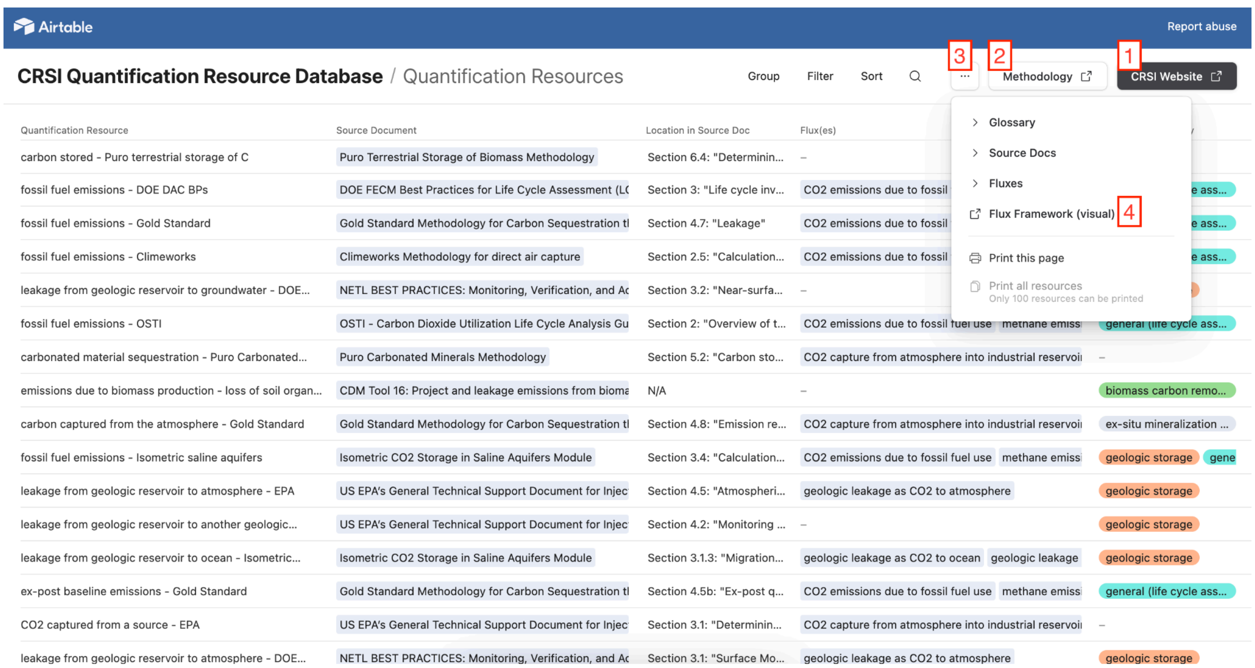
Using the Database

You can access the Database in Airtable [here](#).

The main page of the Database is the Quantification Resources table.

From the Quantification Resources table, you can navigate to:

1. The CRSI website.
2. This methodology document.
3. The Glossary, Source Documents table, and the Flux table in Airtable.
4. The Carbon Reservoir & Flux Framework visualization in Miro.

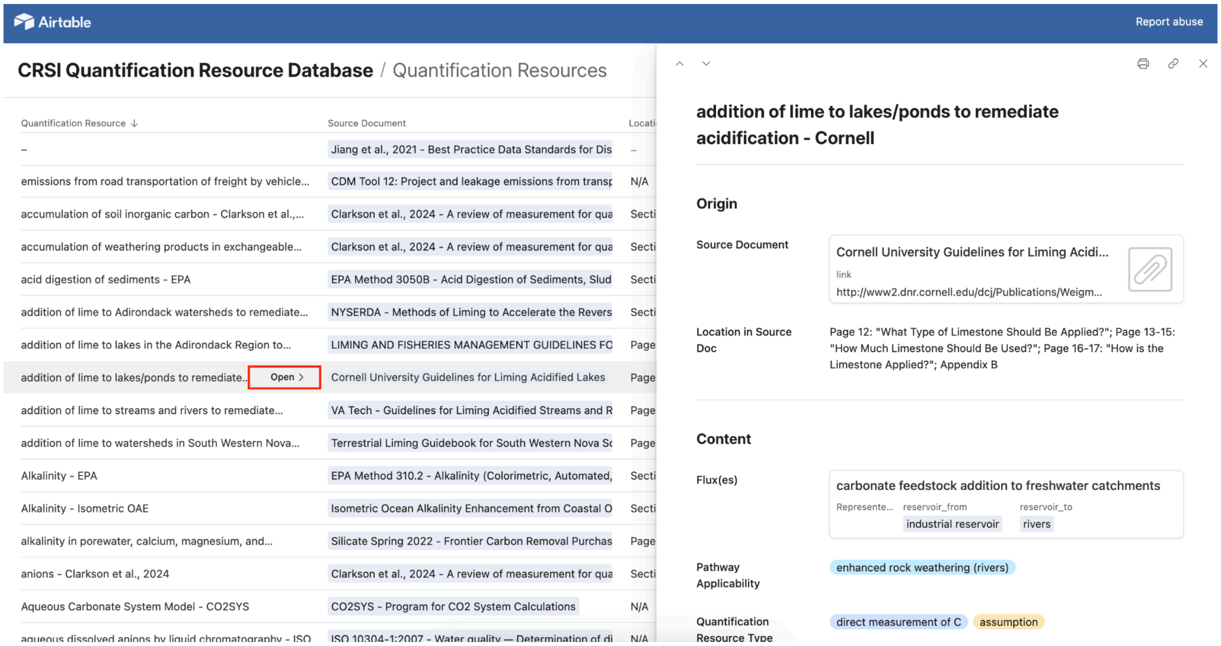


The CRSI website, methodology document, and Flux Framework visualization open in new tabs.

The Glossary, Source Documents table, and Flux table open in the same tab, and are all implemented in Airtable. From the Glossary, Source Documents table, and Flux table, you can only navigate back to the Quantification Resources table.

In each table, you can group, filter, sort, and search the entries.

Clicking on the “Open >” button on the right side of an entry opens a sidebar with all of the available information on that entry. This page can be shared with a link or printed.



Questions and Feedback

If you have any questions, or any feedback on the structure, content, or usability of the Database, please email us at database@carbonremovalstandards.org.