**Methodology: Ranking, Site Assessments & Volumetrics**

### Assessment Methodology

1. **Overview**
   - Assess reservoir potential
   - Reservoir & seal quality
   - Regional/subregional seals
   - Mappable seals

2. **Reservoir & Seal Assessment/Ranking**
   - Reservoir quality
   - Seals: presence, thickness, quality
   - Mappable seals

3. **Estimate Storage Volume**
   - Reservoir type
   - Potential storage volume

4. **Potential Storage Area**
   - Basins
   - Regional/subregional seals
   - Mappable seals

### Ranking Methodology

- **Assessment methodology for storage sites involved three components:**
  - Reservoir effectiveness, and
  - Reservoir depth (does not automatically fail if < 800 m)

- **The ability to assess each area is dependent on the quality and spatial distribution of the available datasets**

- **Does not dismiss a reservoir due to lack of data - allows for uncertainty due to lack of data**

- **It does not consider factors such as interference with other resources, land usage, distance to CO2 emission nodes or calculated volumetric estimates**

### Common QLD Data Types

- **Well data (QPED & WCR's), outcrop (GSQ maps)**
  - Reservoir characteristics
    - Porosity, permeability, production history, lithology, continuity, thickness
  - Seal characteristics
    - Capacity, lithology, thickness, continuity

- **Seismic data (3D)**
  - Structure, faults, potential traps, migration and leakage paths, reservoir & seal distribution
  - Depth-structure maps

- **Oz SEEBASE™ depth to basement (high level screening tool)**

### Queensland CO₂ Storage Atlas

- **Aim to identify with highest possible certainty prospective basins for geological storage in onshore Queensland (16 basins).**

- **Geological assessment - excludes existing resources**

- **Options assessed include:** regional reservoirs (saline reservoirs & aquifers), depleted oil & gas fields; deep unmineable coal seams; and salt caverns.

- **Greatest potential in regional reservoirs using migration assisted storage (MAS) - focus of regional assessments and volumetric assessments.**
Potential Storage Area Mapping

- Maps generated for the maximum known extent of reservoir-seal intervals within a basin that are evaluated as having potential for geological storage of CO₂.
- The maximum potential storage area incorporates:
  - A regional seal >800 m deep at its base.
  - A seal of suitable thickness to contain CO₂ (>50 m for conventional seal; >100 m for unconventional seal).
  - A suitable quality reservoir for CO₂ (porosity > 0.1%; permeability > 5 mD).

- However, the level of detail in mapping maximum potential storage area varies from basin to basin depending on the data availability and geological complexity.
There are different mechanisms which immobilise (trap) CO₂ in the subsurface, and the timescales over which they operate (Bachu et al. 2007).

The lower three mechanisms (dissolution, mineralisation and adsorption) are, mostly, very long-term and are not considered here further.

The volumetric estimations calculated in this atlas are based around free-phase trapping; i.e. top four mechanisms.

**Volumetric Methodology**

- Under the normal range of pressure/temperature conditions found in sedimentary basins, the density of CO₂ can vary significantly.
- Uses the industry standard method of calculating CO₂ density of a saline system based on the temperature data (Span and Wagner 1986).
- The precision of the CO₂ density estimate depends on the accuracy of pressure and temperature estimates.
- Data obtained from CSIRO Pressure Datasheets, then cross-checked with well data (ideally 10-20 data points).

CO₂ density given two end-member basin conditions: a hot fresh-water (red curve) and a cold saline-water basin (blue curve).

**Eromanga Basin – Hutton Sandstone e.g.**

- Hutton sandstone = Jurassic fluvial sandstone
- Good-excellent reservoir potential
- Can be cemented at maximum depths in the central depocentre
- Intraformational seal = Birkhead Fm (known to seal hydrocarbons); regional seal = Allaru Mudstone & Wallumbilla Fm.

Potential Storage Area for the Eromanga Basin, defined by depth > 800m and > 50m thickness of regional seal (Allaru Mudstone/Wallumbilla Fm).

**Eromanga Basin – Hutton Sandstone e.g.**

Calculate temperature and pressure gradients from WCRs:
- Temperature gradient ~8.8°C/km based on extrapolated RHT data from 12 wells
- Pressure gradient ~4,355 psi/m combined from groundwater studies and ten selected well DST’s and RHT’s.

Calculate CO₂ density gradient:
- Supercritical below 440 m SS
- The high geothermal gradient means that there is a relatively lower CO₂ density at any depth compared to other ‘colder’ basins (e.g. southern Bowen Basin)

**Volumetric Methodology**

- The migration assisted storage (MAS) process is the main process that can theoretically store enormous quantities of CO₂, in the absence of any subsurface closure.
- The dominant primary trapping mechanism is discontinuous free-phase trapping as residual gas saturation (RGS) in the tail of a migration plume.
- Using the reservoir cut-offs a residual gas saturation (Sgr) of 0.2-0.8 is likely but other values are possible, with higher Sgr being more conservative. Therefore a likely conservative value of Sgr = 0.1 has been used for all volumetric calculations.
- Ultimately the CO₂ trapped by these mechanisms is dissolved into the surrounding formation water.

**Eromanga Basin – Hutton Sandstone e.g.**

- Structural and stratigraphic trap filling
- Migration assisted storage (MAS)
- Residual assisted storage (RAS)
- Cementation assisted storage (CAS)
- Organic matter assisted storage (OMAS)
- Mineral (dissolution, precipitation) assisted storage (MAS)
- Heat assisted storage (HAS)
Volumetric Methodology

The equation for volumetric estimation is:

\[ M_{CO_2} = RV \times \varnothing \times S_g \times \delta_{(CO_2)} \]

- \( M_{CO_2} \) = mass of CO\(_2\) stored in kilograms
- \( RV \) = total reservoir rock volume in m\(^3\)
- \( \varnothing \) = total effective pore space (as a fraction)
- \( S_g \) = the gas saturation within the above pore space as a fraction of the total pore space (10%)
- \( \delta_{(CO_2)} \) = the density of CO\(_2\) at the given reservoir depth (pressure and temperature) in kg/m\(^3\).

Volumetric Methodology

- This volumetric estimation calculation overestimates the value: calculating the volume of CO\(_2\) that could be stored over the entire reservoir unit.
- As the migrating plume will not access a large proportion of the reservoir this value is unrealistic (assuming homogeneous reservoir injection over entire interval, & formation water displaced uniformly)
- Therefore to limit extreme values developed a very basic RGS storage efficiency factor
- 15m plume estimate used

As the reservoir thickness increases, a smaller proportion of the total reservoir volume can be theoretically considered as potentially available for storage.
Volumetric Methodology

- Attempted to be conservative in estimating all the parameters used in the volumetric estimated potential storage calculation. It is therefore believed that the estimates given are conceptually close to the boundary between theoretical and effective capacity.

- All estimates have accompanying data quality tables and descriptions of input parameters used (see previous table).

And the results?

- Next presentation: Results and conclusions of the Queensland CO2 Geological Storage Atlas