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Assessing the CO_2 Storage Potential of the Western Eromanga and Pedirka Basins, Australia

CO_2 Storage Conference, Aberdeen, 2 October 2024

Adam Borushek and Barny Brennan
RISC Advisory

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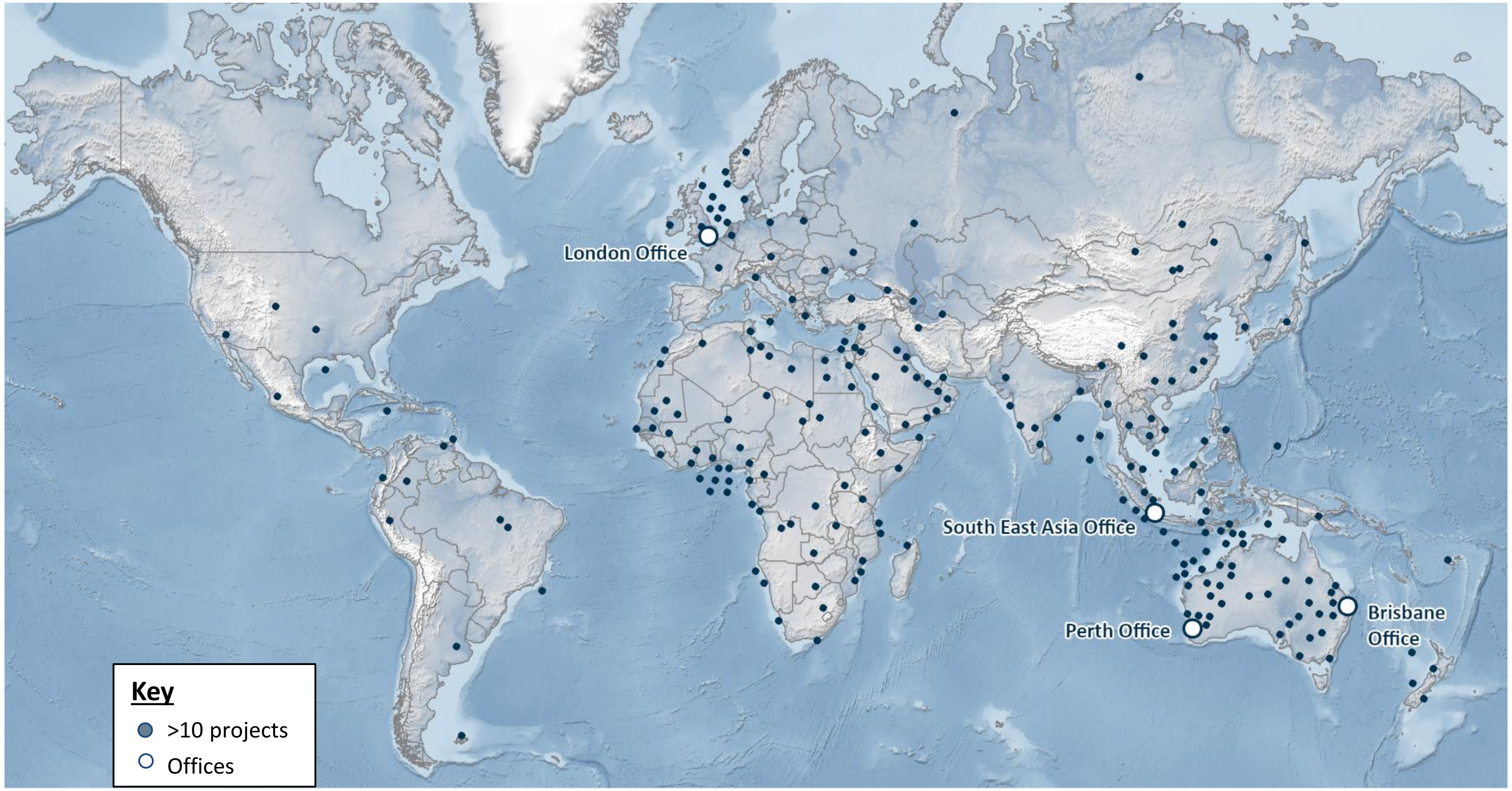

Our Services

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RISC provides independent, insightful and impartial advice to our clients across a range of services

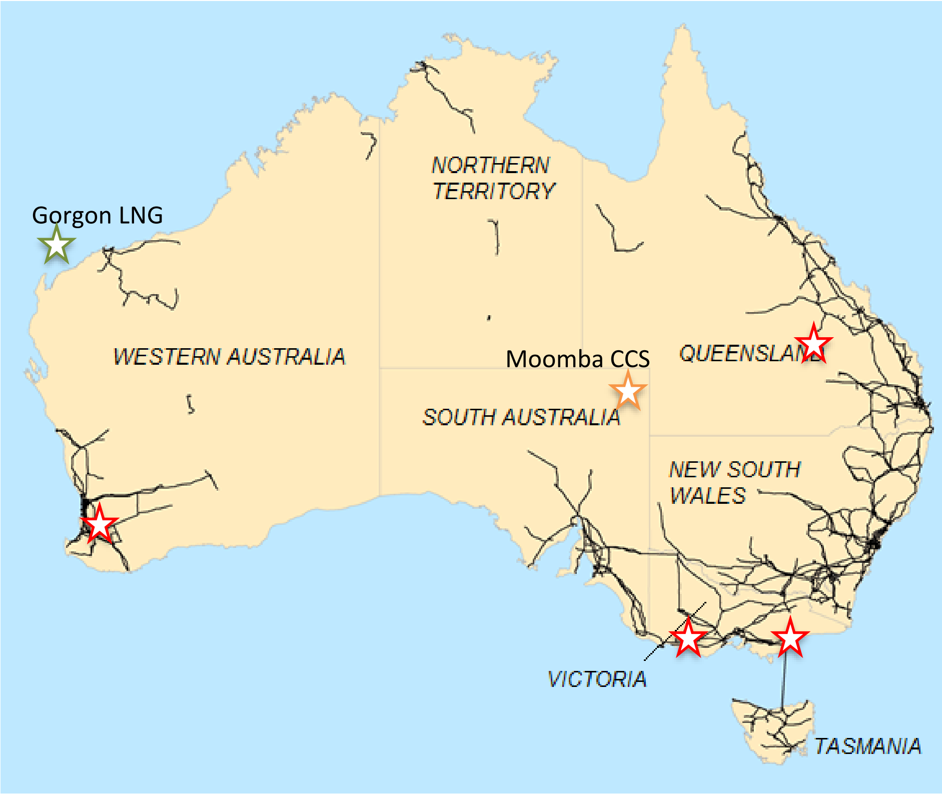
Due Diligence	***Identifying critical issues and creating value***
Reserves and Resources	***Audit, Assessment and Evaluation of resources***
Independent Technical and Expert Reports	***Independent, comprehensive and impartial advice***
Technical Advice	***Revealing opportunities and creating value***
Commercial and Strategic Advice	***Helping responsible investment and development***
Expert Witness	***Helping resolve differences of opinion***
Energy Transition	***Pathfinding the route to low emissions energy***
Environmental Social and Governance	***Helping responsible investment and development***
Acquisitions and Divestments	***Guiding the transaction processes***

Australia – CO_2 Storage Summary

Australia has ambitious Net Zero goals that require CCS

- Australia has legislated 2030 targets for emissions reductions, and a goal of Net Zero by 2050.
- However, it also has significant primary resource industries that are CO_2-intensive and 'hard-to-abate'.
- CCS is a solution available for reducing emissions from heavy industries such as iron and aluminium, steel, cement, fertiliser and chemical manufacturing, natural gas processing and 'blue' hydrogen production.
- Australia has 1 operating commercial-scale CCS project (Gorgon LNG) and several commercial-scale projects at various stages of development.

- Geoscience Australia's 'Exploring for the Future' program provides precompetitive information to government, community and industry.
- Geoscience Australia worked with RISC to assess the regional potential of carbon storage in the Western Eromanga and Pedirka Basins.



Australian electricity transmission lines (Geoscience Australia)

Eromanga and Pedirka Basins – CCS Potential?

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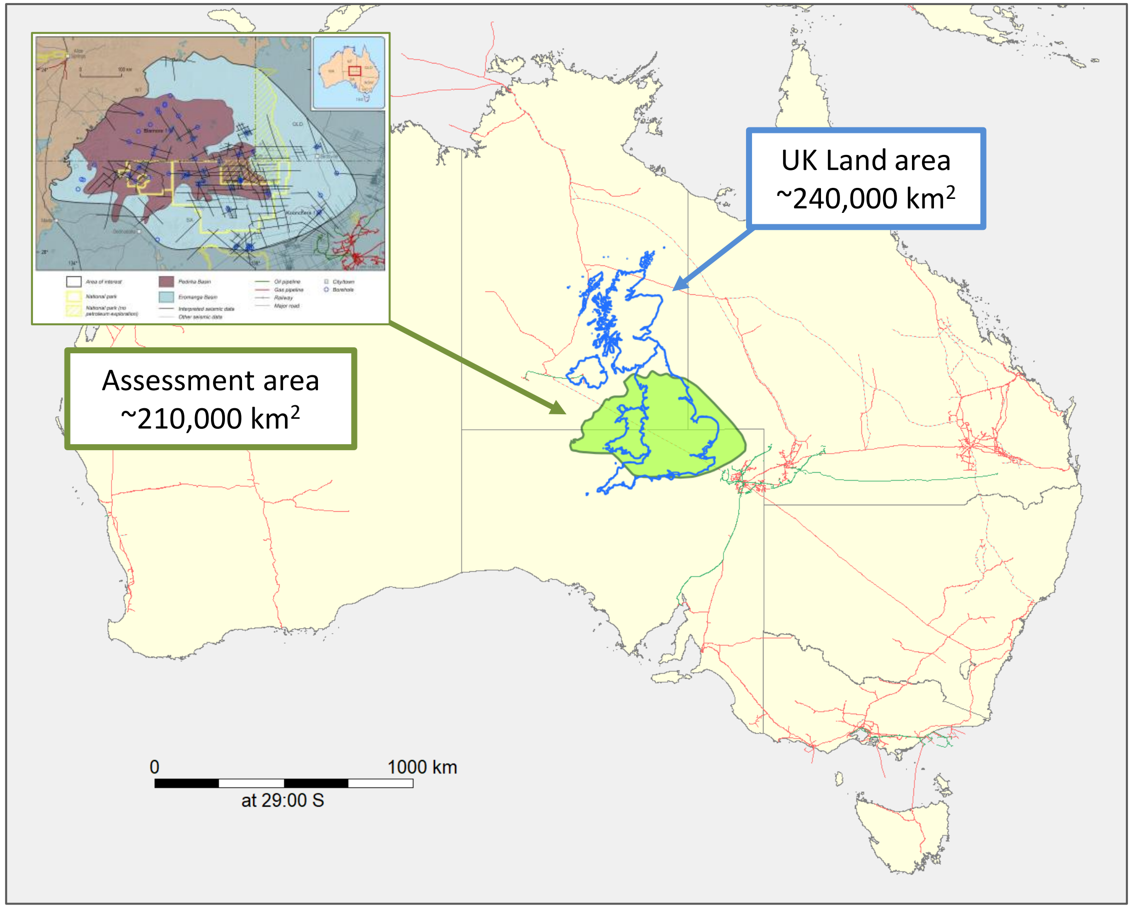
CCS storage sites are being studied as part of Australian government's long-term net-zero plans

CCS potential is being studied in several basins:

- Part of Australia's commitment to transition to 'net-zero' emissions.
- Identifies storage resource areas of interest
- First step before progressing projects up the storage resource pyramid

Why the Eromanga / Pedirka Basin?

- A well-studied onshore basin that has produced oil and gas for over 60 years
- Regional and basin-scale shale and stratigraphic baffles between the formations
- Limited large-scale faulting and moderate to low structural complexity
- Favourable reservoir properties (permeability, pressure, temperature, geology)



CCS Evaluation - Project Objectives

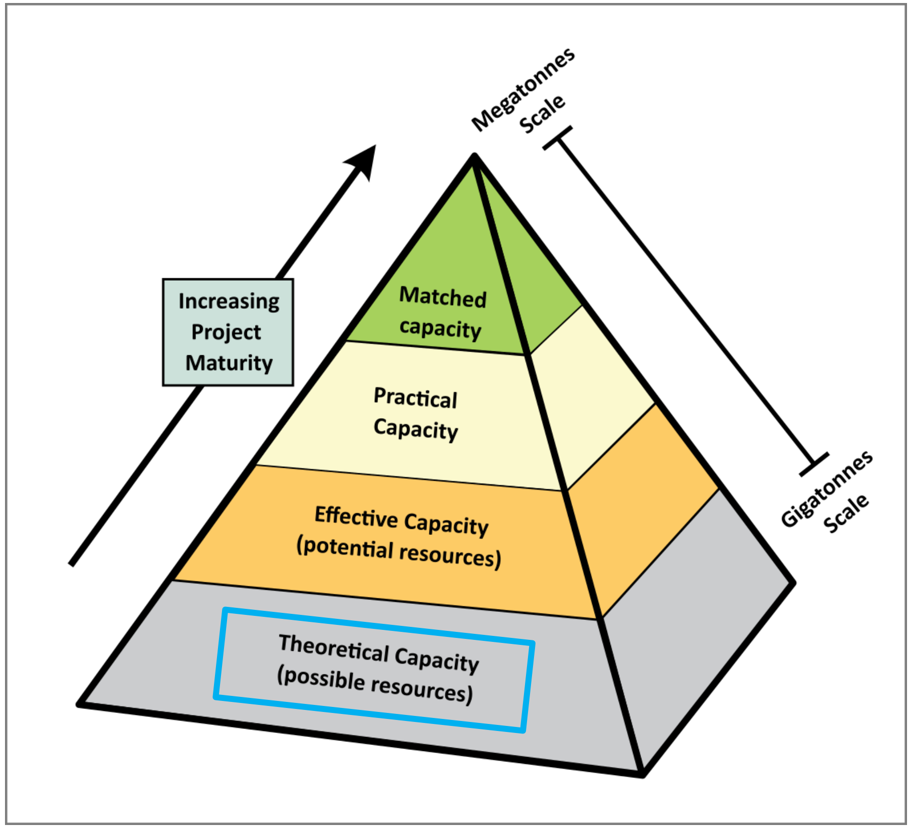
RISC provided engineering support to better define potential storage estimates

A Collaborative project between Geoscience Australia and RISC Advisory:

- Geoscience Australia has defined stratigraphy and pore volumes
- RISC Advisory evaluated storage efficiency factors and fluid properties
- Estimated Ultimate Storage (EUS) range established with guidance from the SPE-Storage Resource Management System (SPE-SRMS)

Project definition is nascent:

- Nearest CO_2 source is the Cooper Basin JV, 300 – 500 km to the south-east
- Low population density - little infrastructure or economic development.
- Storage resources sit within the **Theoretical Capacity** at the base of the resource pyramid.



After Ringrose P. (2023). *Storage of Carbon Dioxide in Saline Aquifers.* Society of Exploration Geophysicists

Exploration Play Based Mapping

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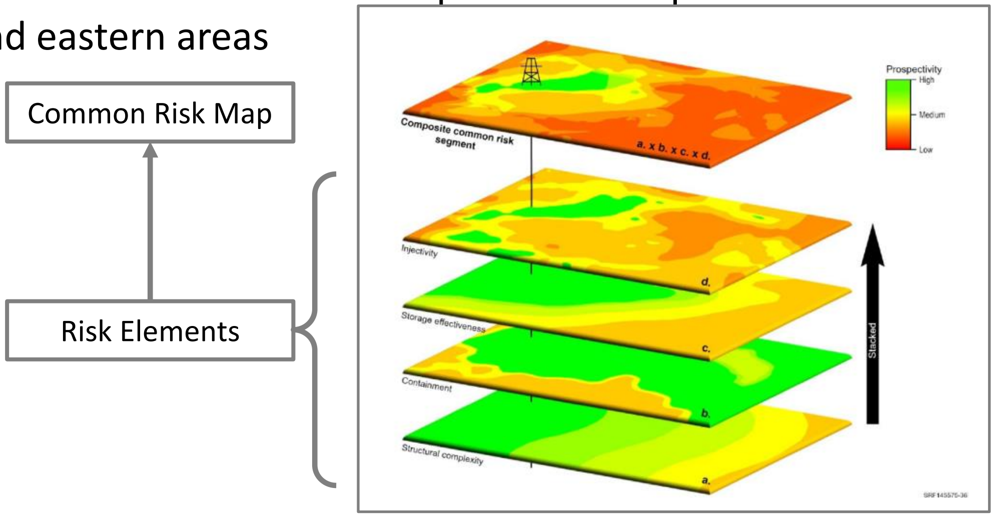
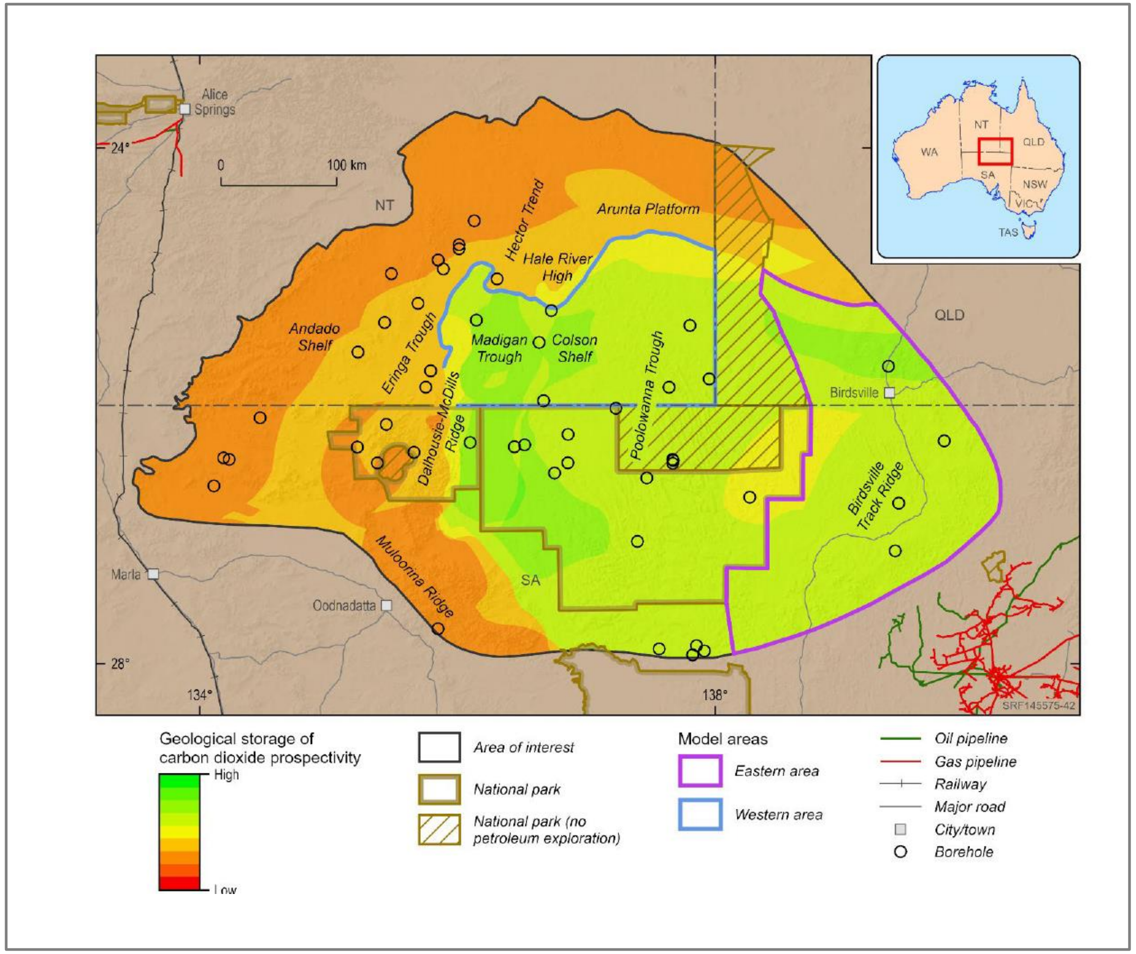
Play mapping used to define lowest risk areas for storage

- Five prospective stratigraphic play intervals identified
- Stratigraphic play intervals identified
- Key risk elements mapped across basin for each play
  - Injectivity
  - Containment
  - Storage effectiveness
  - Structural complexity
- Combined common risk map shows best potential in central and eastern areas



Schematic illustrating process

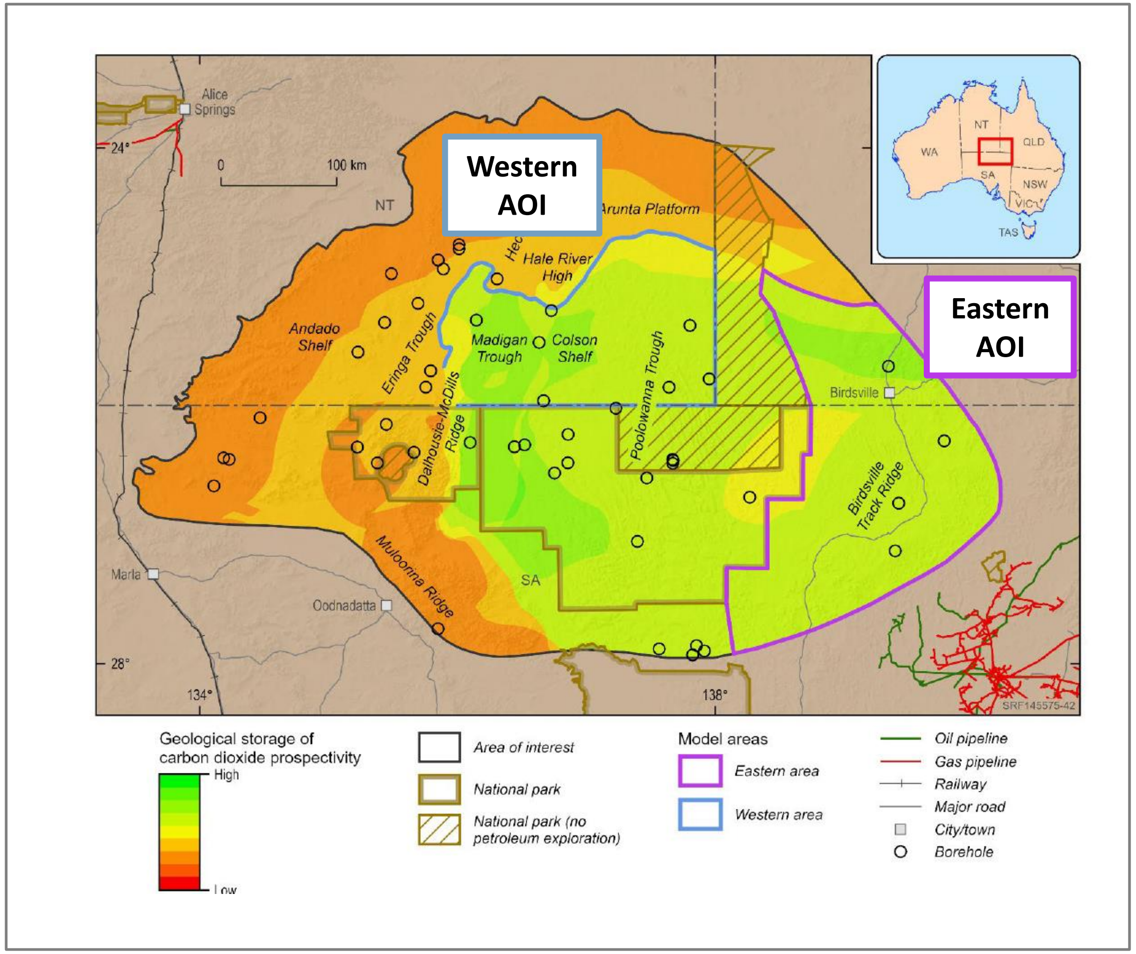


Combined common risk map for the five plays

High Graded Areas of Interest

Two AOIs identified based on CRS mapping and regulatory restrictions

- Total area before high-grading = 210,000 km^2
- High-graded area (**green shading** on CRS map) = 119,000 **km^2**
- Strategic areas avoided:
  - National Parks and environmentally restricted areas
  - Proximity to natural springs and outflows
  - Proximity to active petroleum exploration and development blocks
- Two areas identified for focused assessment – **Eastern** (**purple**) and **Western** (**blue**) AOIs:
- East + West area = 63,000 km^2



Combined common risk segment for the five plays

Pore Volume

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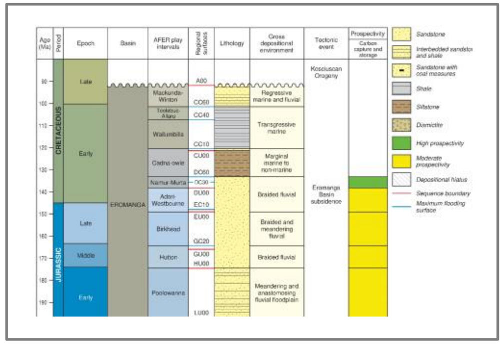
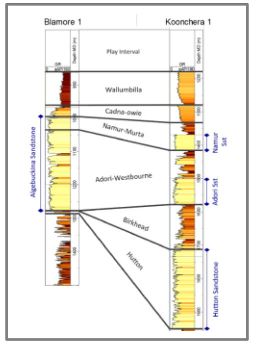
Pore volume computed from basin-scale static model

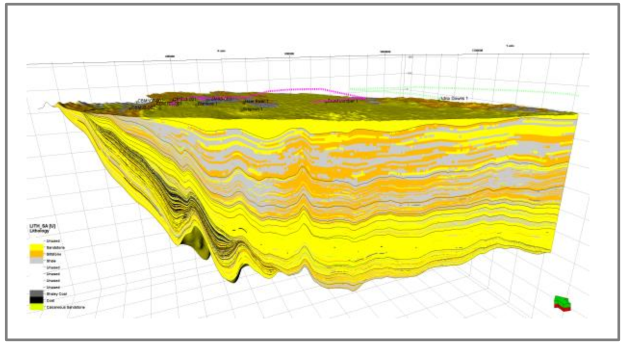
- Structural and stratigraphic framework defined from 2D seismic and wells
- Static model constructed to capture
  - Geological Facies – Sandstone/Siltstone/Shale/Coal distributed using well control data
  - Effective Porosity – how much volume can we use for storage?
  - Permeability
- 9,450 km^3 prospective net pore volume available for storage in good quality, sandstone reservoir and saline water, of which 4,750 km^3 in eastern and western AOIs.



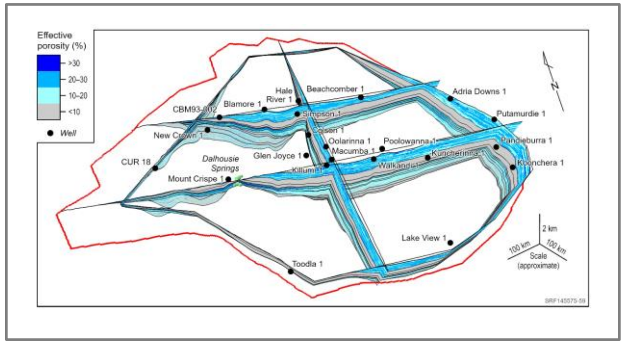
Basin-wide Lithology



Well Stratigraphy and correlations



Geological Facies Model



Property Model

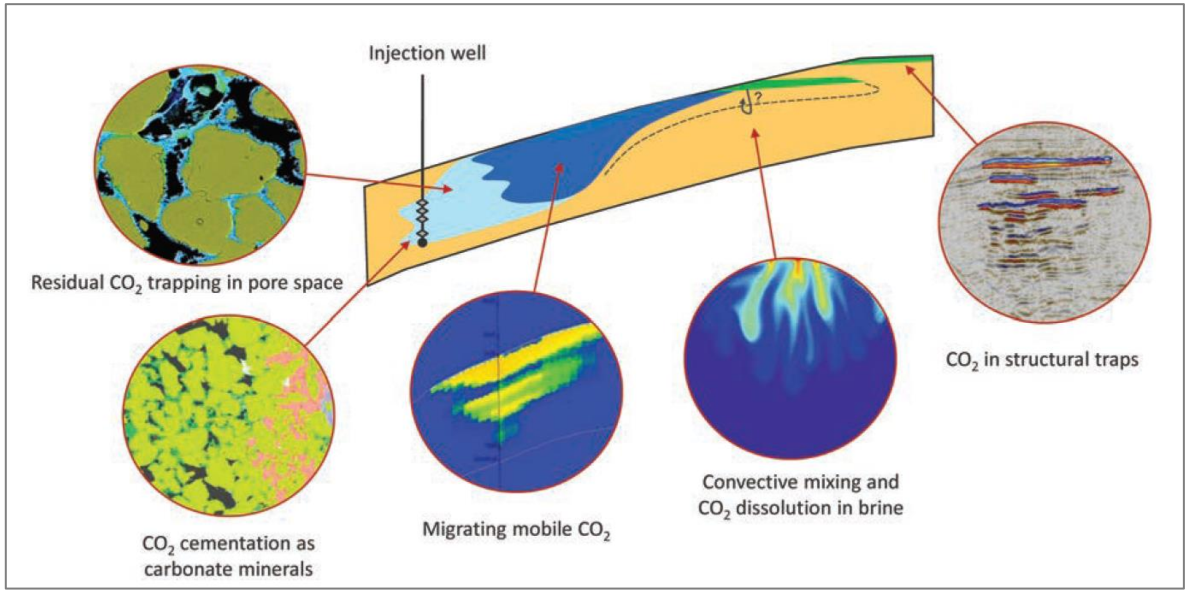
$$\mathbf{CO_2\ Storage\ Mass} = \mathbf{Pore\ Volume\ x\ Efficiency\ Factor} \times \mathbf{CO_2\ Density}$$

CO_2 Storage Evaluation

Constraints on storage efficiency in an open saline aquifer were evaluated

- The basins were considered an open aquifer for this project with high reservoir permeability and good lateral connectivity
  - Storage area and volume are *not* confined by a discrete structure
- Vertical and lateral migration will be slowed by low permeability shales and lower quality reservoir
- Microscopic pore-scale physics impacts the range of storage volumes

Multiple mechanisms involved in the storage of CO_2



Ringrose P. (2023). *Storage of Carbon Dioxide in Saline Aquifers.* Society of Exploration Geophysicists

$$\mathbf{CO_2\ Storage\ Mass = Pore\ Volume\ x\ Efficiency\ Factor \times CO_2\ Density}$$

Trapping Mechanisms for Saline Aquifers

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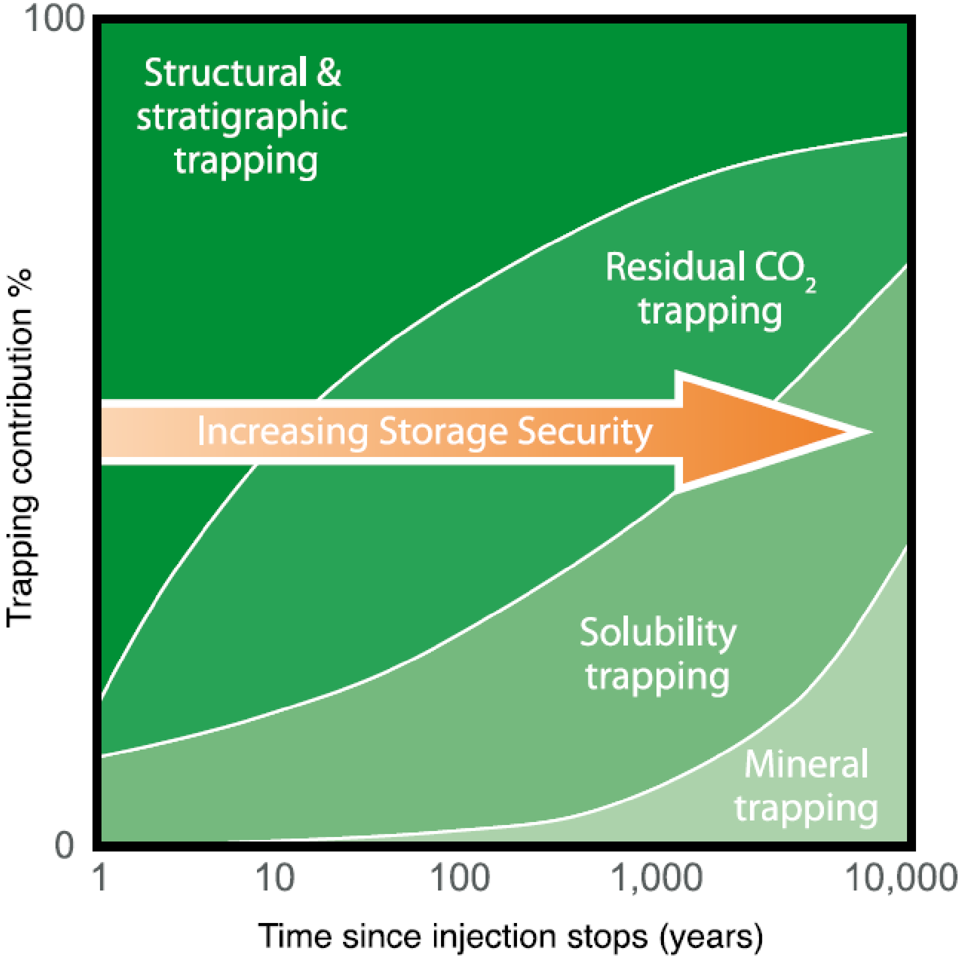
The short-medium term mechanisms were estimated

Mechanisms

- No structural or stratigraphic traps, only the slight formation dip
- Significant residual CO_2 trapping
- Significant CO_2-brine solubility
- Mineral trapping not considered (very long-term)



Storage Efficiency Factor (EF)

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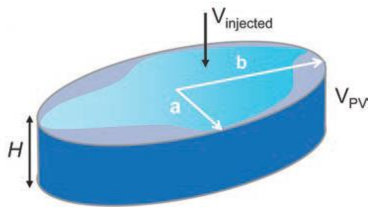
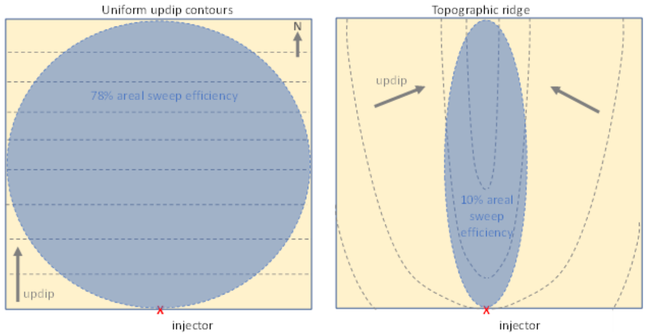
Storage Efficiency factor included areal, vertical and microscopic components

E_a – Areal Efficiency

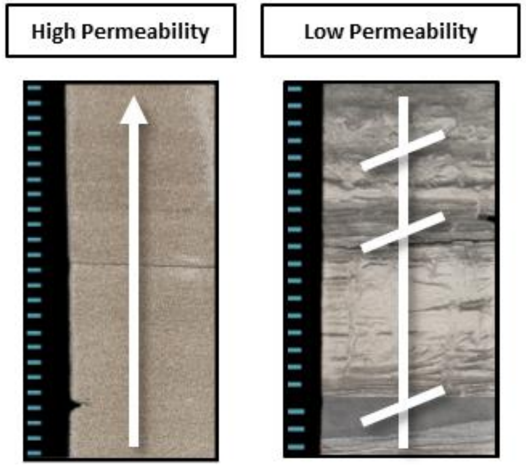
- Assumed an ellipse of injected CO_2 to account for lateral geological heterogeneity in each formation
- Range: 50-70%





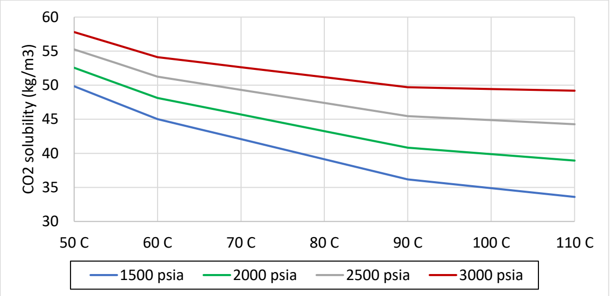
E_v – Vertical Efficiency

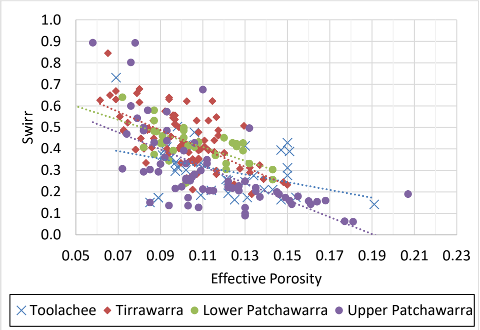
- High vertical permeability → lower Ev
- Test models to relate kv/kh to Ev
- Accounts for flow barriers/baffles
- Range: 5-30%



E_d – Microscopic Storage Efficiency

- Residual gas saturation (25% of PV)
- CO_2 brine solubility (7% of PV)
- Range: 20-45%





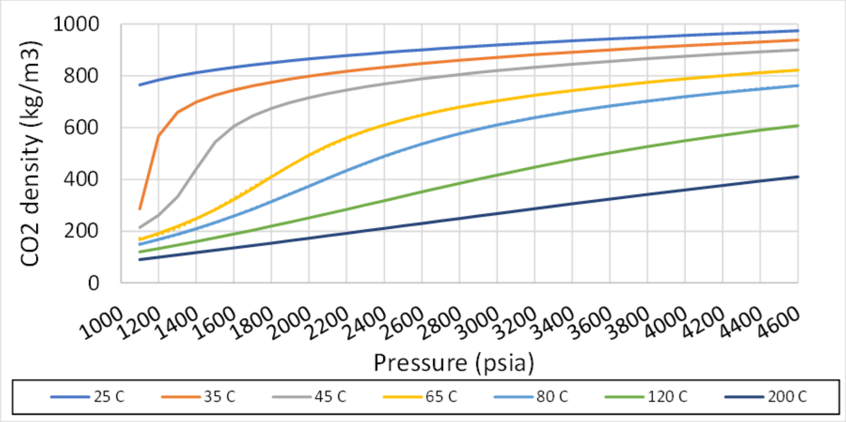
CO_2 Density and Fluid Parameters

Fluid density and fluid properties estimated with industry-standard correlations, calibrated to lab data

- Fluid model for CO_2 density, related to depth:
  - **Increases** with increasing reservoir **pressure**
  - **Decreases** with increasing reservoir **temperature**

- Storage reservoirs are ideal when CO_2 can be stored in a 'dense phase'.
  - For the Western Eromanga project area, reservoirs deeper than ~700m

Density vs Pressure at various Temperatures



CO_2 Density and Fluid Parameters

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- Fluid model for CO_2 density:

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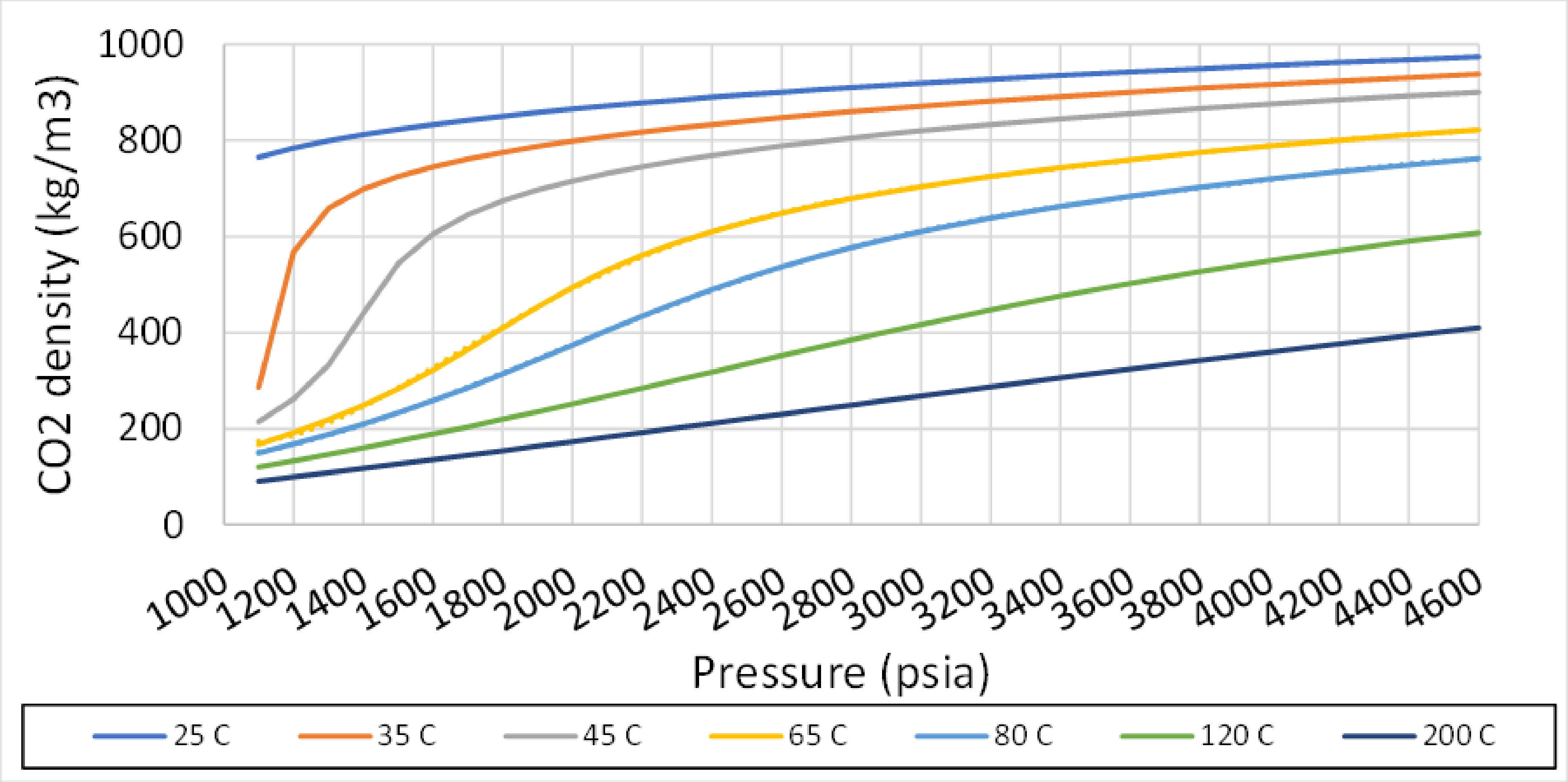

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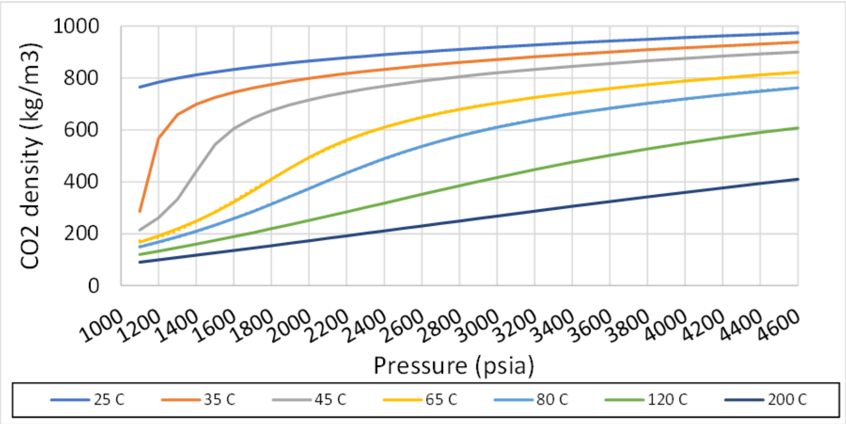
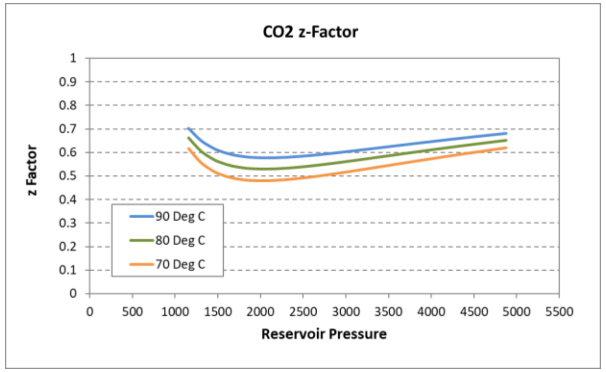
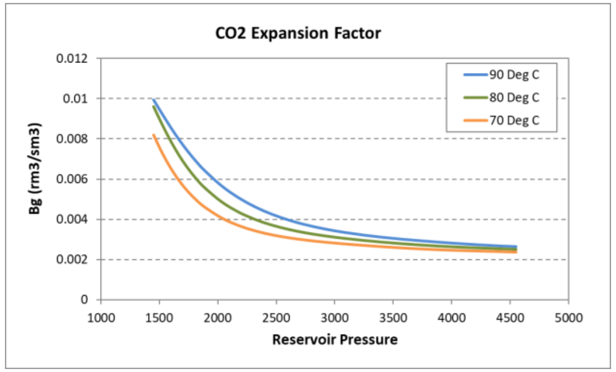
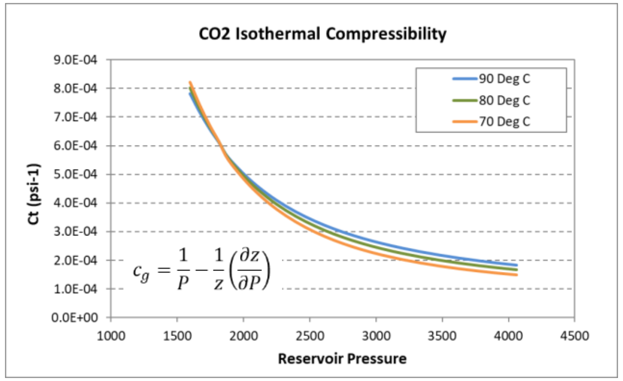


- Correlations for pure CO_2 applied for the pressure and temperature
- CO_2 isothermal compressibility, super-compressibility (z), expansion factor, and viscosity generated using industry standard correlations:







EUS and Uncertainty

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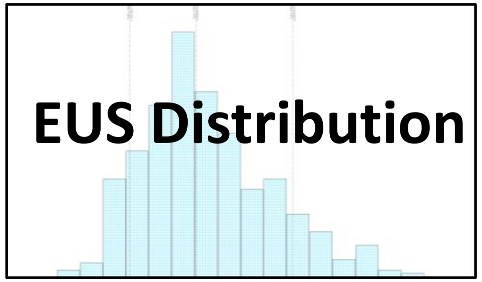
Uncertainty was modelled in a Monte Carlo simulation, supported by Deterministic low, mid and high cases

CO_2 Storage Mass = PV × EF × CO_2 Density



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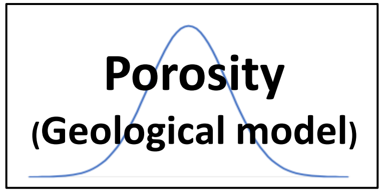
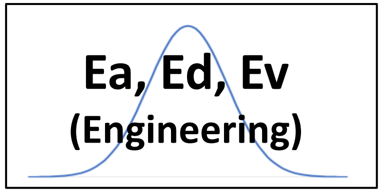
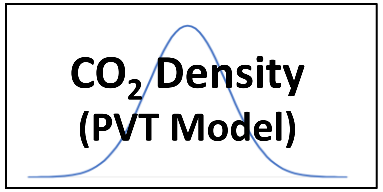
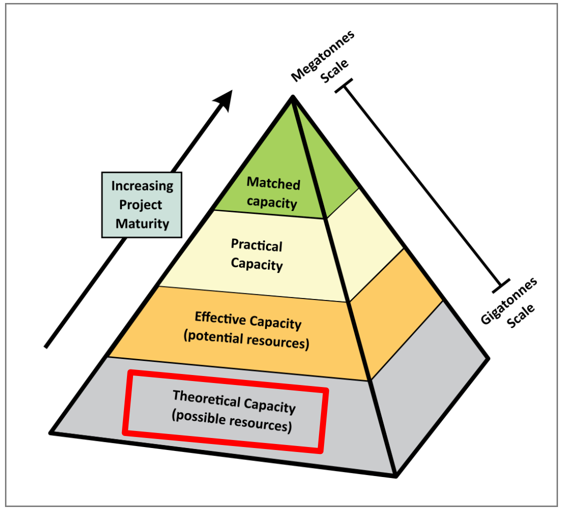






	East and West EUS Mt CO_2
Low (P90)	123,600
Mid (P50)	181,000
High (P10)	265,600



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Conceptual Project Development Parameters

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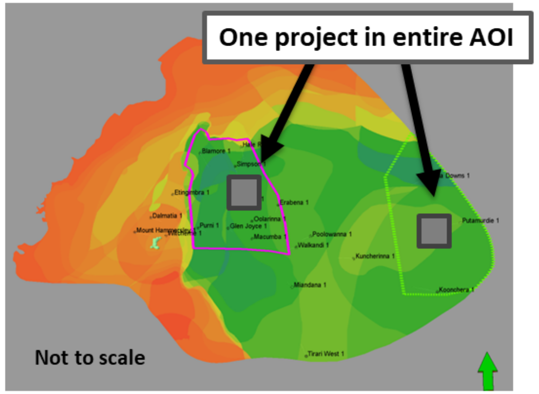
A 50 Mt project would require 3 - 4 CO_2 injection wells. Base assumption is an infinite acting aquifer.

Development Project Concept

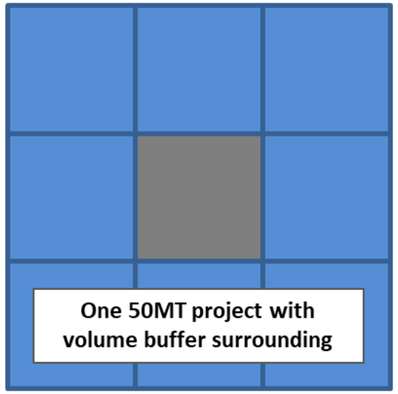
- Injection of 2.5 Mt of CO_2 per year for 20 years
  - This is 50 Mt or 950 Bscf of CO_2.
- Injection into all five formations equally with 3-4 CO_2 injection wells.
- Project area is circa 30-50 km^2
- Well-connected aquifer: constant reservoir pressure throughout the project life.

- Downside: 3 cases of water injection depending on infinite acting, semi-closed, and full closed aquifers

Case 1
Infinite Acting



Case 2
Semi-Closed



Case 3
Closed

One 50MT project constrained to one 50MT equivalent area

Conceptual Project: Water Wells Required?

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RISC investigated the impact of aquifer assumptions on reservoir pressures. Water offtake may be required to manage pressures during long-term injection projects.

Open aquifer

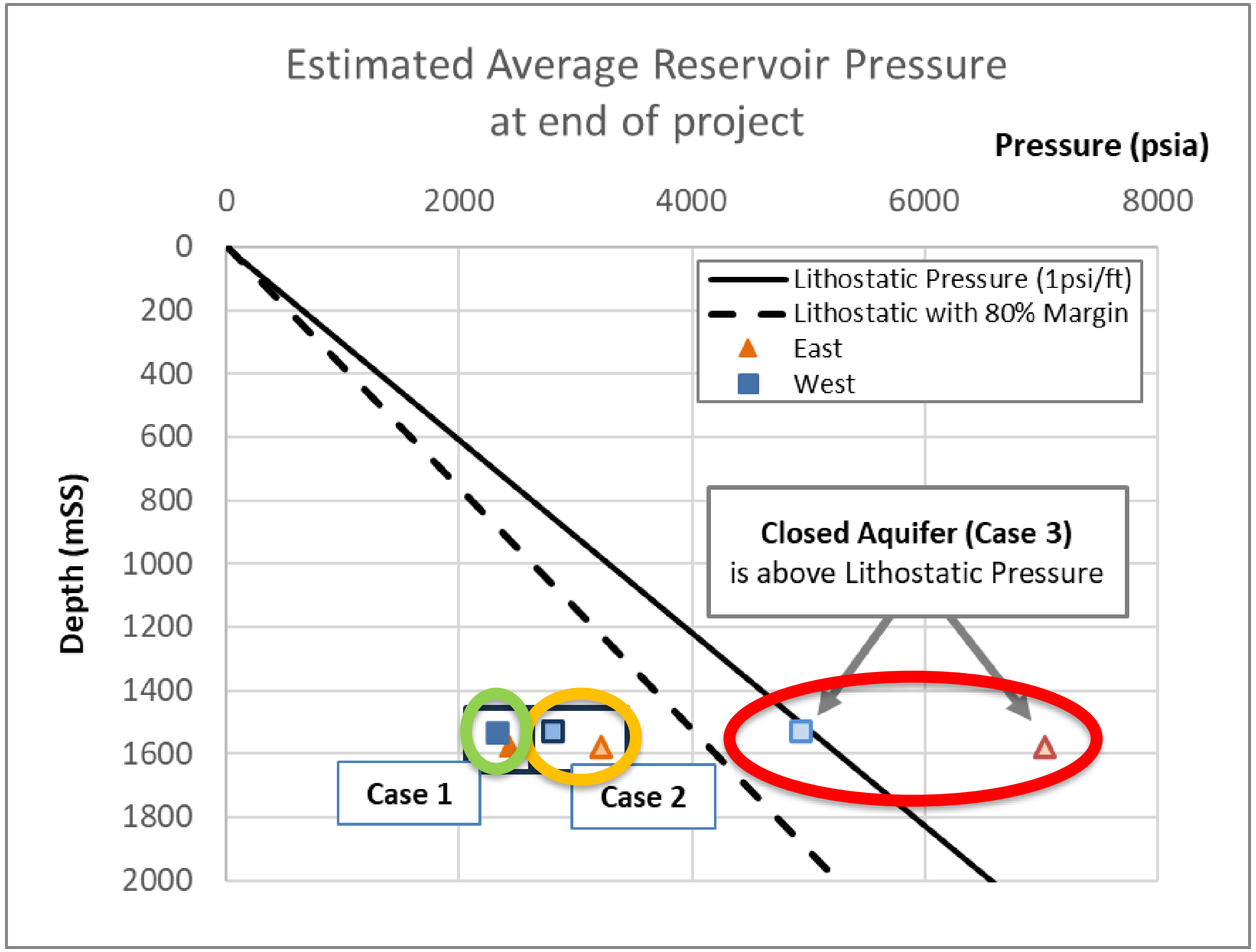
- All injection pressure is displaced. No pressure change. No water production needed.

Semi-closed aquifer

- A 50 MT project will not case average reservoir pressure to exceed lithostatic pressure
  - However, pressures at the well may be higher. Careful injection management would be required.

Closed aquifer

- A 50 MT project WILL exceed lithostatic pressure without pressure management.



Conceptual Project: Water Wells Required?

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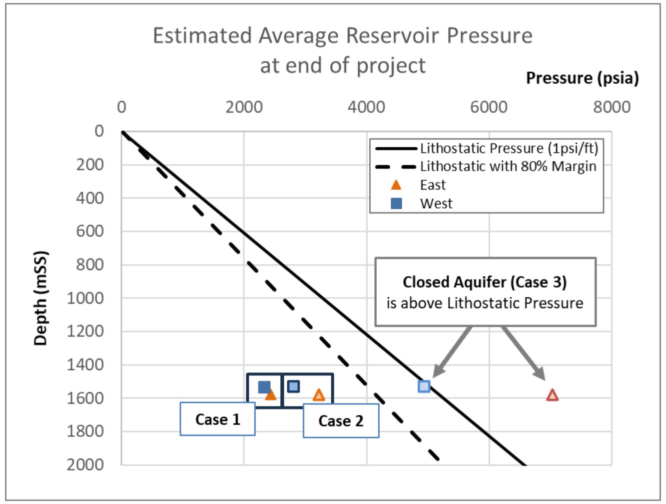
Closed aquifer

- A 50 MT project WILL exceed lithostatic pressure without pressure management.

We reviewed 2 pressure management options with water producers

- 100% voidage balance. Circa 15,000 tonnes/day, 8 water wells
- Managed safe pressure rise with a 20% safety margin to lithostatic pressure. Circa 10,000 tonnes/day, 5 water wells



Development Scenario	Reservoir Pressure at end of project	Total Extracted Water
Closed Aquifer Full voidage balance	No Change	754 MMSTB
Closed Aquifer Managed to lithostatic pressure w/ safety margin	Increase 1640 psi	415 MMSTB

SRMS EUS Volumes

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The volume estimates fall outside the SRMS, without Project Definition or Resource Entitlement

Project Definition:

- A conceptual project has indicative scale and feasibility.
  - Range of injection rates and water offtake
- Source of CO_2? Economics?

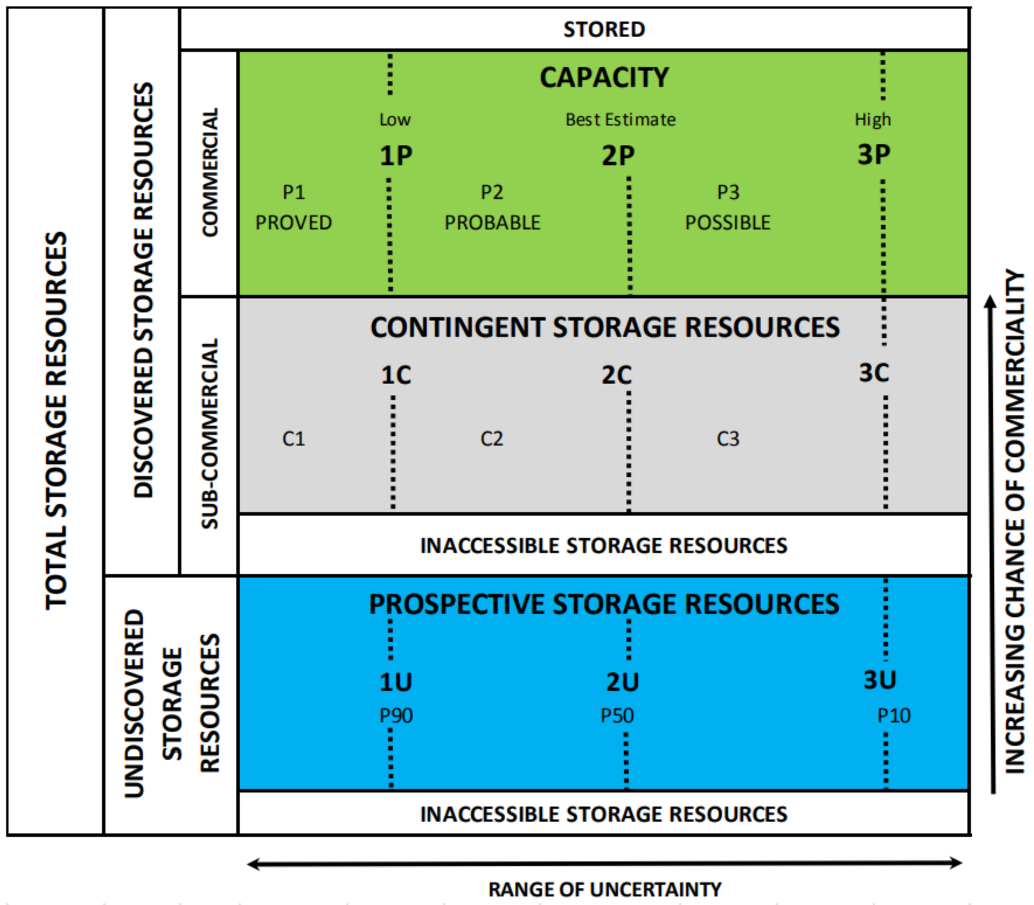
Storage Entitlements:

- No storage licenses issued in this basin yet
- Government regulation and cooperation is still an evolving story

Classification

- After licences awarded.

SRMS Storage Resource Matrix



Conclusions

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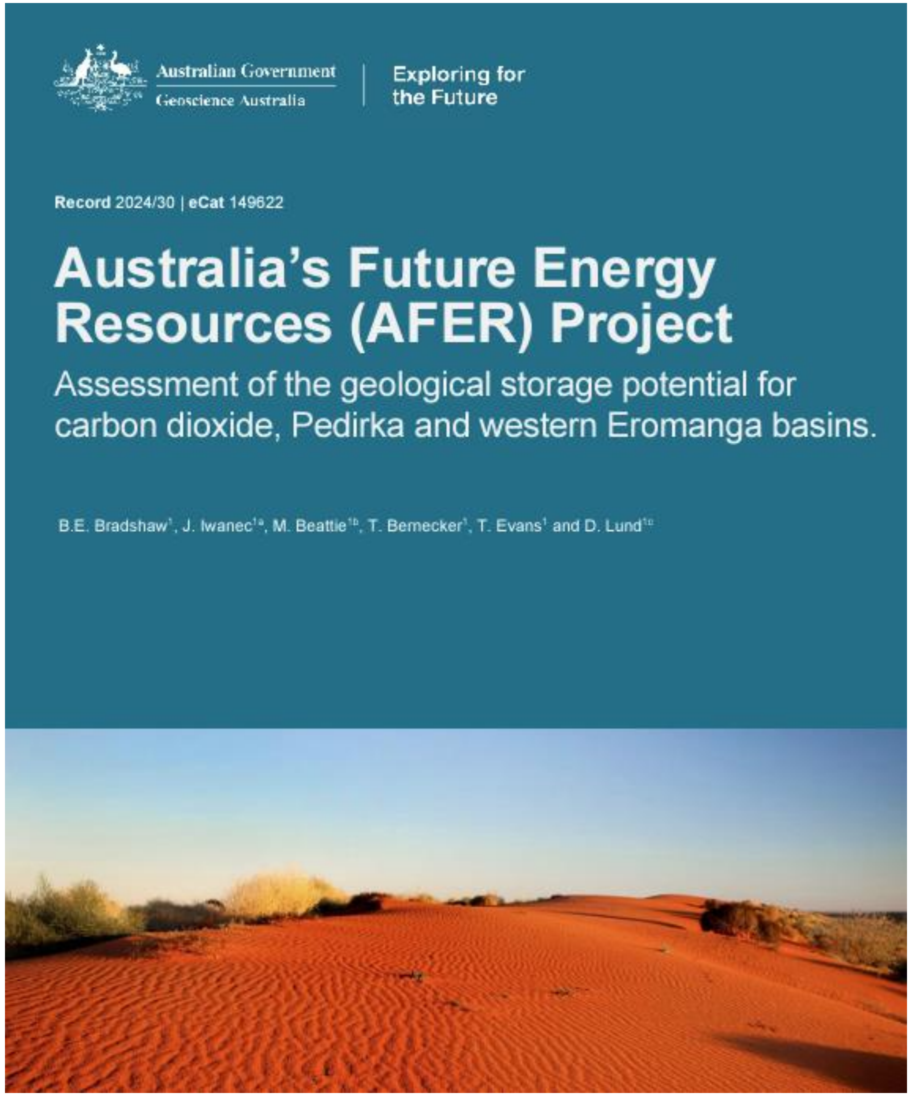
- Geoscience Australia and RISC Advisory demonstrated the potential storage volumes in the western Pedirka-Eromanga basin.
- These areas can support multiple industrial-scale storage projects, with pressure management if needed.
- Updated workflow: maps and volumes can now be updated quickly as new geological data are collected to infill knowledge gaps.
- Geoscience Australia published their report, now available for public download.
- Results will be used to inform activities of industry (including operators and emitters), communities, and the state governments of Northern Territory, South Australia and Queensland.



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https://ecat.ga.gov.au/geonetwork/srv/eng/catalog.search#/metadata/149622

References

See these for more detail:

- Geoscience Australia report: Australia's Future Energy Resources (AFER) Project
  - 'Assessment of the geological storage potential for carbon dioxide, Pedirka and western Eromanga basins. '
  - https://d28rz98at9flks.cloudfront.net/149622/149622_00_0.PDF

- CO_2 Storage Resources Management System (SRMS)
  - https://www.spe.org/en/industry/co2-storage-resources-management-system/
  - https://www.spe.org/media/filer_public/0d/3e/0d3efcb5-57a8-4db2-ac94-6a1be0de61df/srms_sep2022_w_errata.pdf

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admin@riscdvisory.com

Backup slides for Q&A

Wide range in Geothermal Gradients

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Geothermal gradients range 3 - 5.9 degC per 100m, leading to uncertainties in CO_2 properties (eg density)

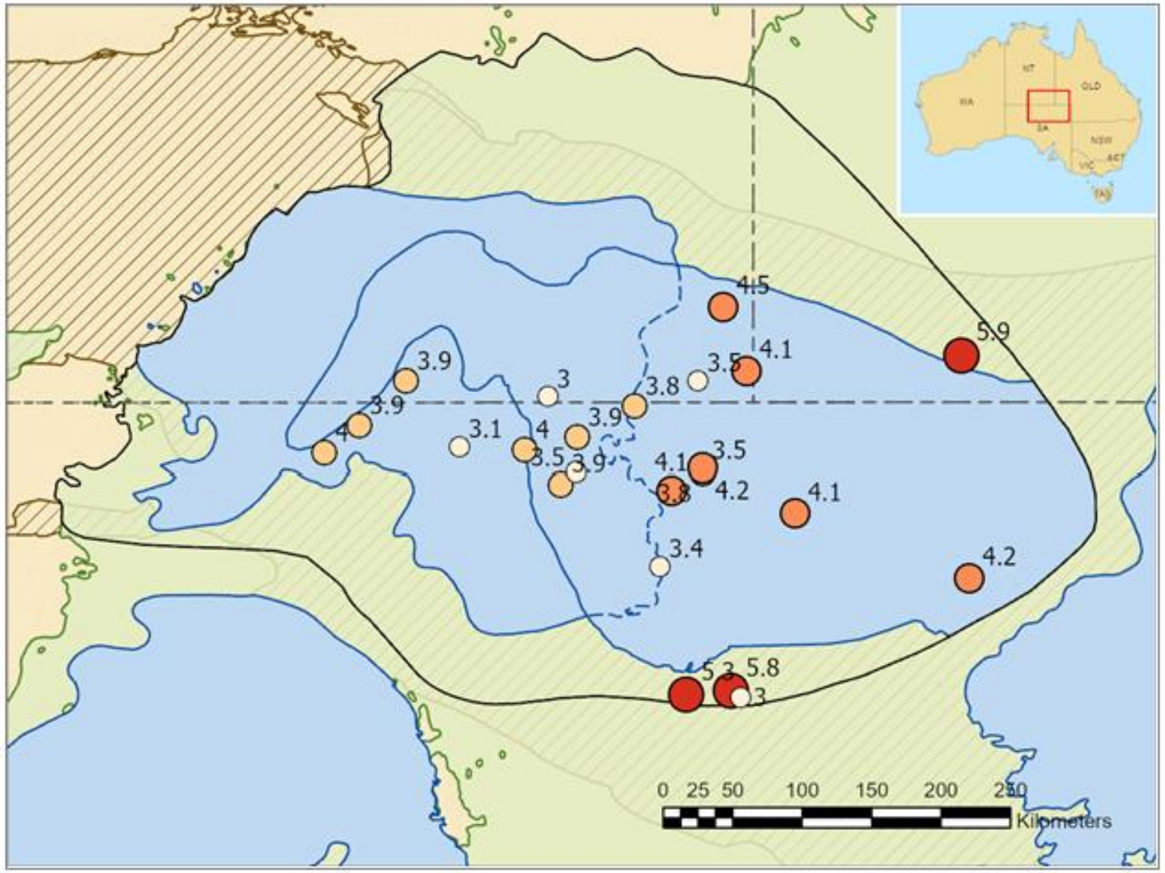
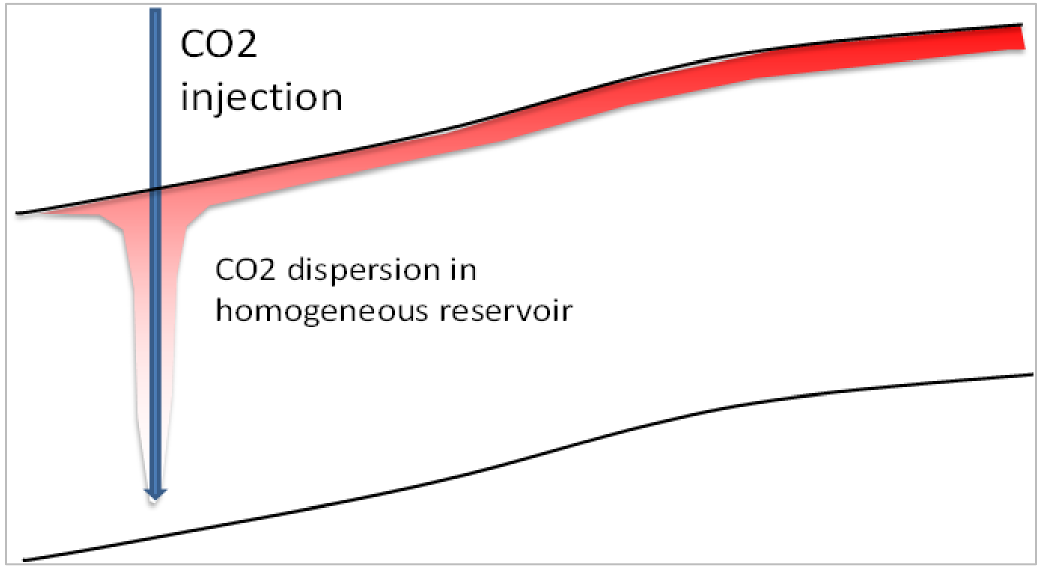


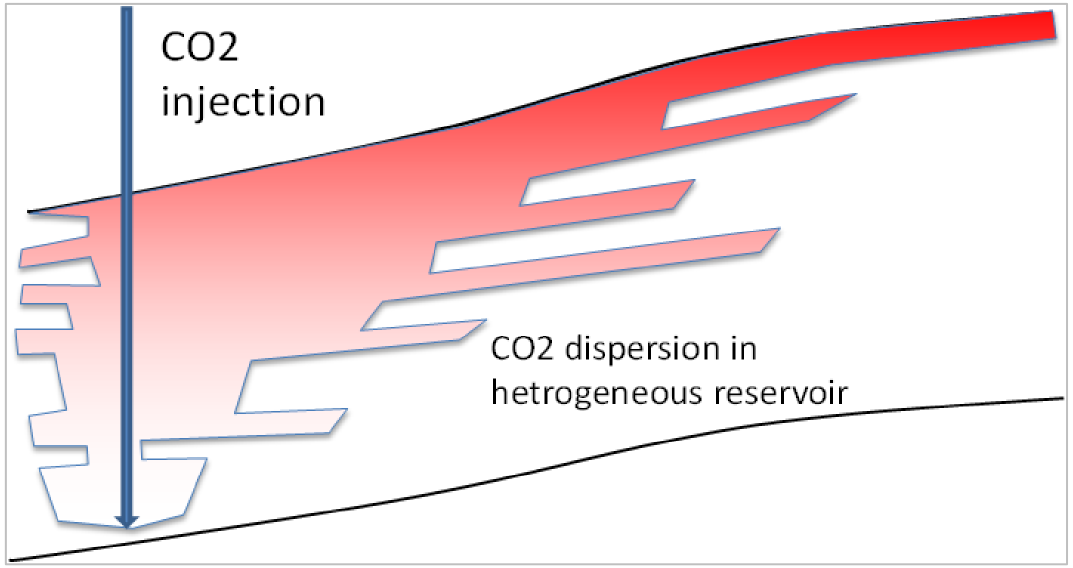
Figure 5-2: Variation in geothermal gradient across the region (Geoscience Australia)

Vertical Heterogeneities Impact Areal Component

Vertical Storage Efficiency is increased if the aquifer consists of stacked layers (with little connectivity), or with permeability variation (higher permeability in the deeper layers)



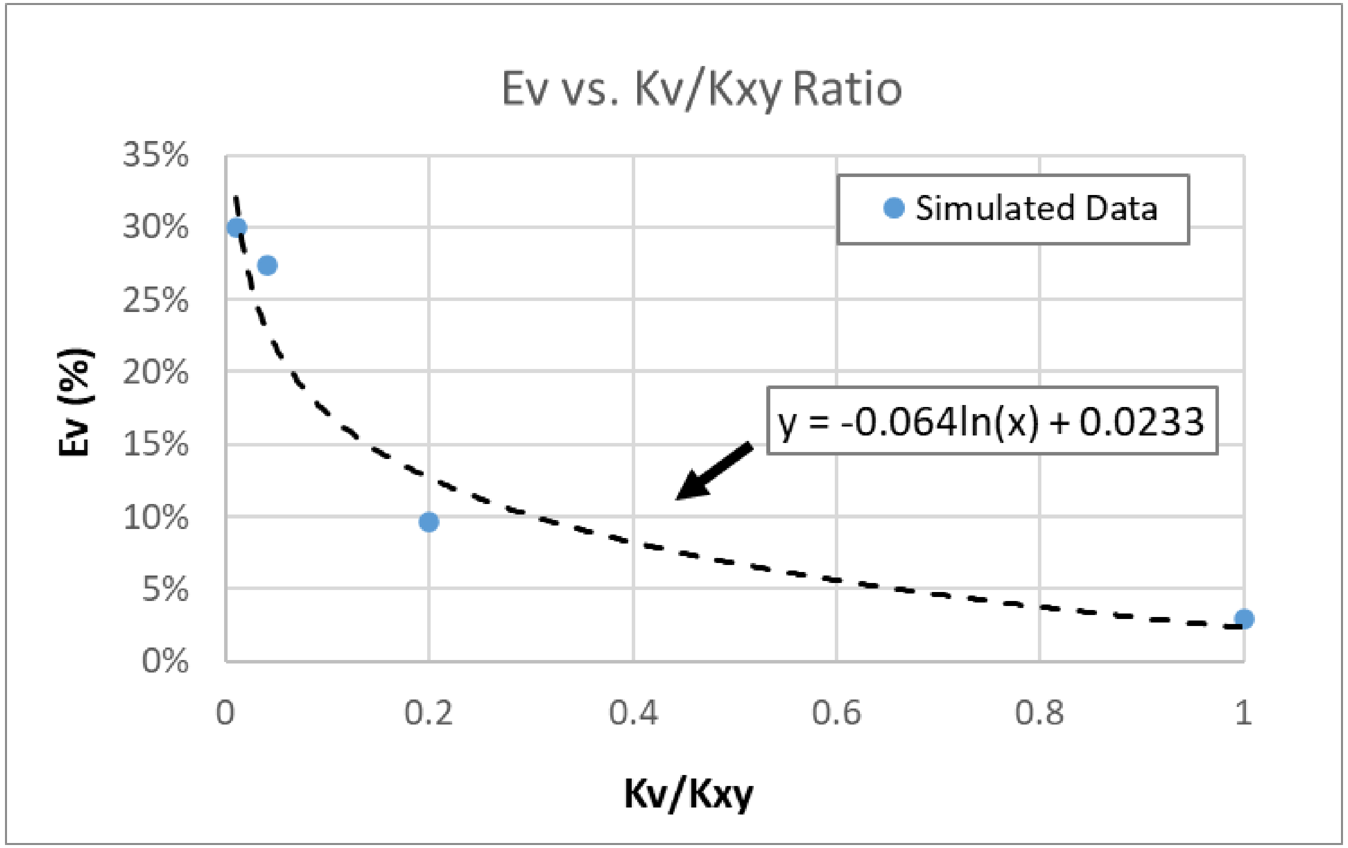
Schematic cross-section of CO_2 injection in a thick aquifer with **good vertical connectivity**



Schematic cross-section of CO_2 injection in a heterogeneous with **limited vertical connectivity**

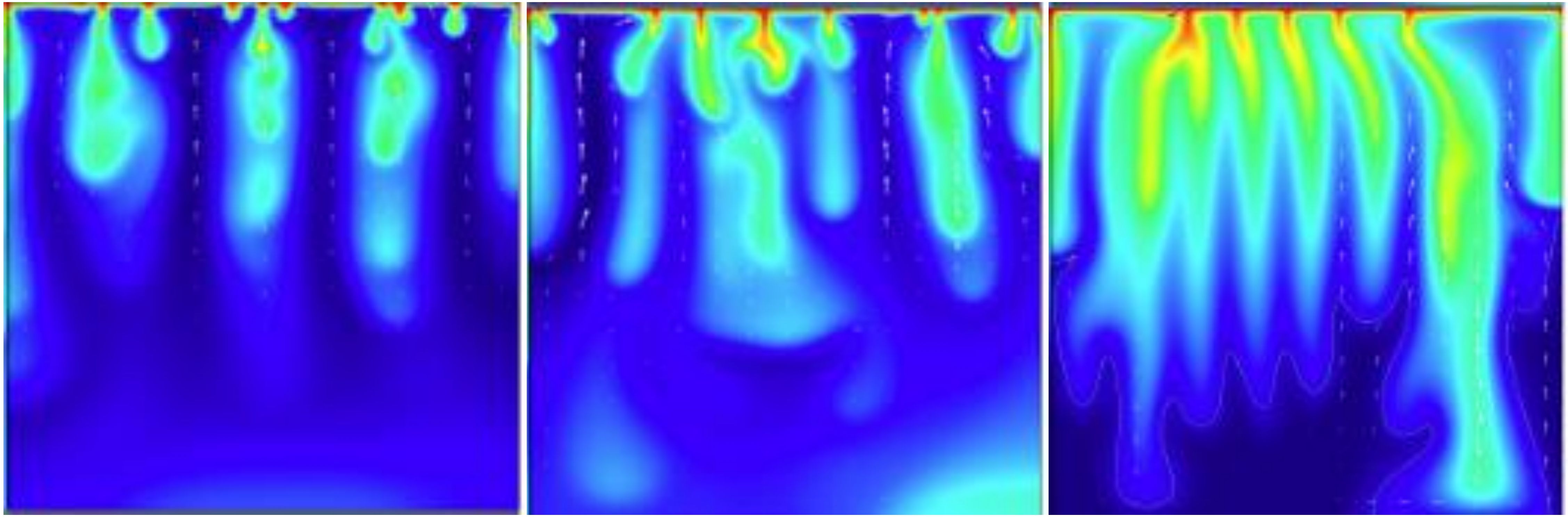
Simulations relating Kv/kh to Ev

We built a simple correlation between the vertical:horizontal permeability ratio, and the vertical component of storage efficiency



Density-Convection Mechanism

This mechanism is not a simple process and requires numerical modelling to account for brine density, vertical and horizontal permeabilities, etc. It presents an upside to the estimated E_v



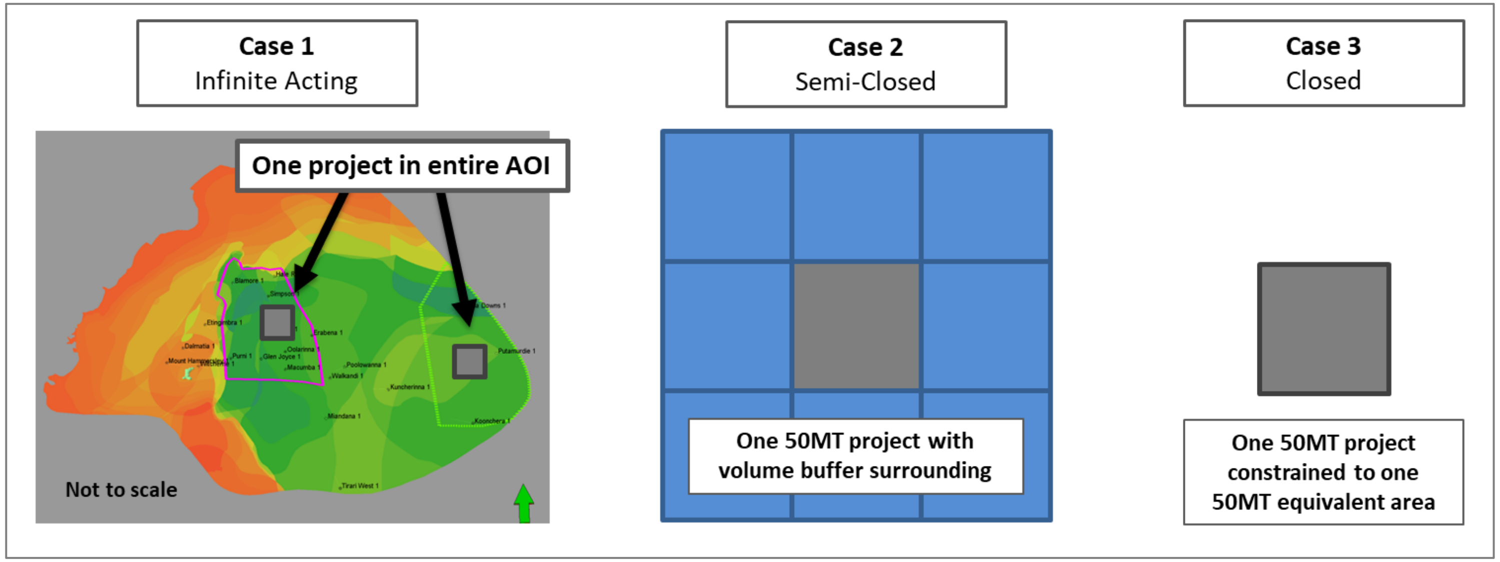
Images from ‘Modeling Pathways and Stages of CO_2 Storage’, E. Holzbecher

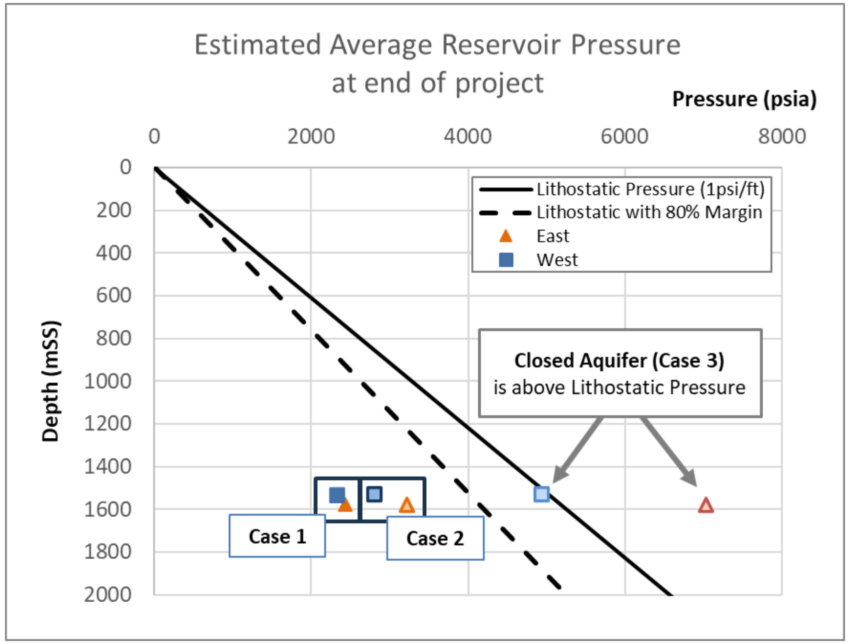
Conceptual Project Connected to Aquifer

Australian Government
Geoscience Australia

RISC

RISC investigated the impact of 3 cases of connectivity to the regional aquifer. Constrained areas require water injection wells to (a) maintain original pressure or (b) keep to safe pressure increases.





www.riscadvisory.com

Perth

Level 2
1138 Hay Street
WEST PERTH WA 6005
P. +61 8 9420 6660
E. admin@riscadvisory.com

Brisbane

Level 10
95 North Quay
BRISBANE QLD 4000
P. +61 7 3025 3397
E. admin@riscadvisory.com

London

Level 2
20 St Dunstan's Hill
LONDON UK EC3R 8HL
P. +44 (0)203 795 2900
E. admin@riscadvisory.com

South East Asia

Jakarta
Indonesia
P. +61 8 9420 6660
E. admin@riscadvisory.com