



Government of **Western Australia**
Department of **Mines and Petroleum**

CCS Projects in Western Australia - Gorgon and Collie Hub

CAGS Summer School Sanya, China,
August 2011

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Outline

- Introduction
 - Western Australia (WA)
 - CCS, CO₂ phase behaviour
 - CO₂ storage media, CO₂ trapping mechanisms
 - Site selection criteria
- Gorgon CO₂ Disposal Project
- Collie South West Hub Project

Western Australia



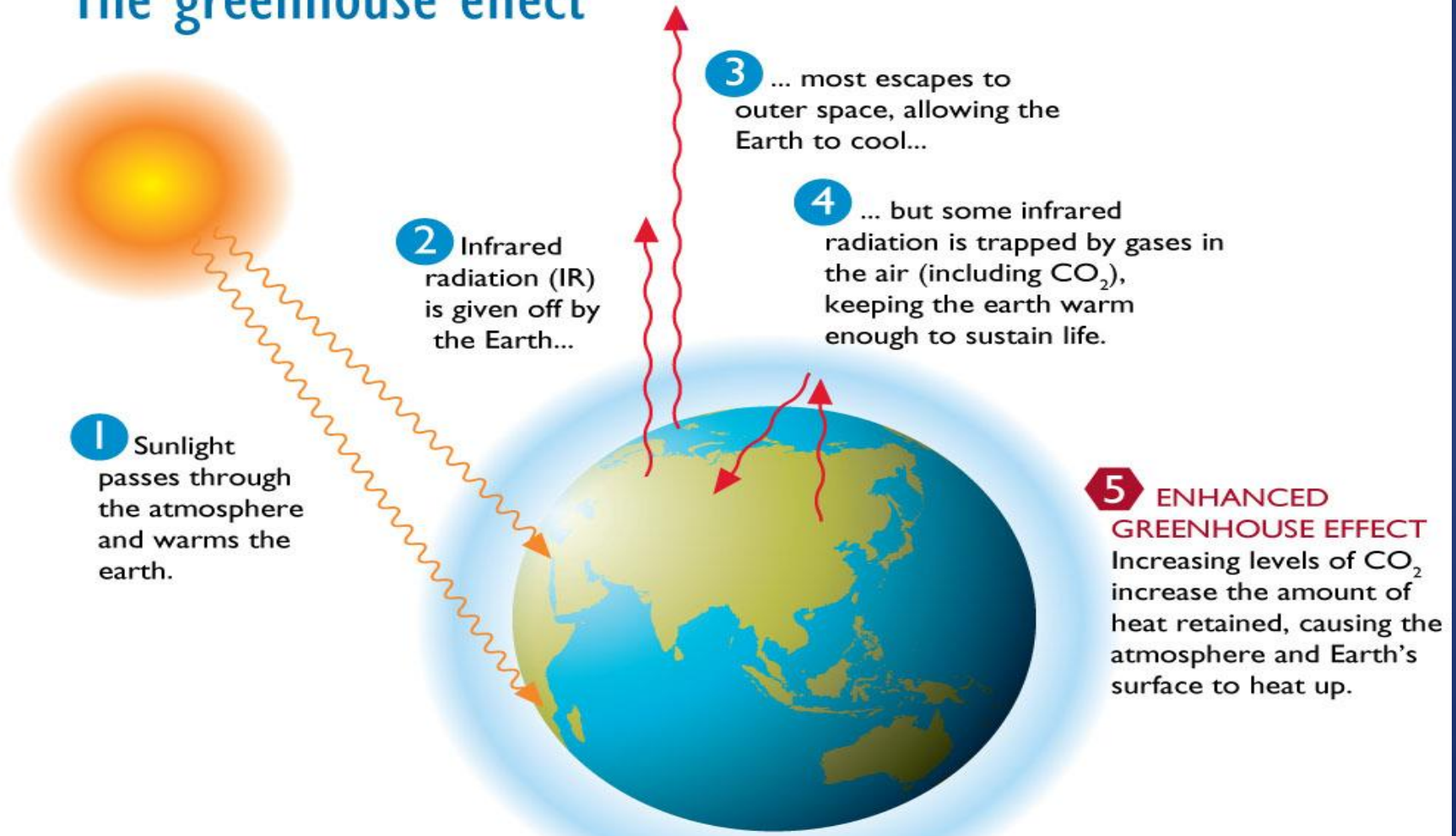
Introduction

- **CCS- Carbon dioxide Capture and (Geological) Storage**
 - a critical component in the global response to reduce Greenhouse Gas emissions from energy sector
- **Greenhouse Gases** – mainly water vapour (H₂O), CO₂, methane (CH₄), Nitrous oxide (N₂O), O₃ (source: wikipedia)
- **Greenhouse gas substance** means:
 - (a) carbon dioxide, whether in a gaseous or liquid state; or
 - (b) a prescribed greenhouse gas, whether in a gaseous or liquid state;
 - or a mixture of (a) and (b) etc ...

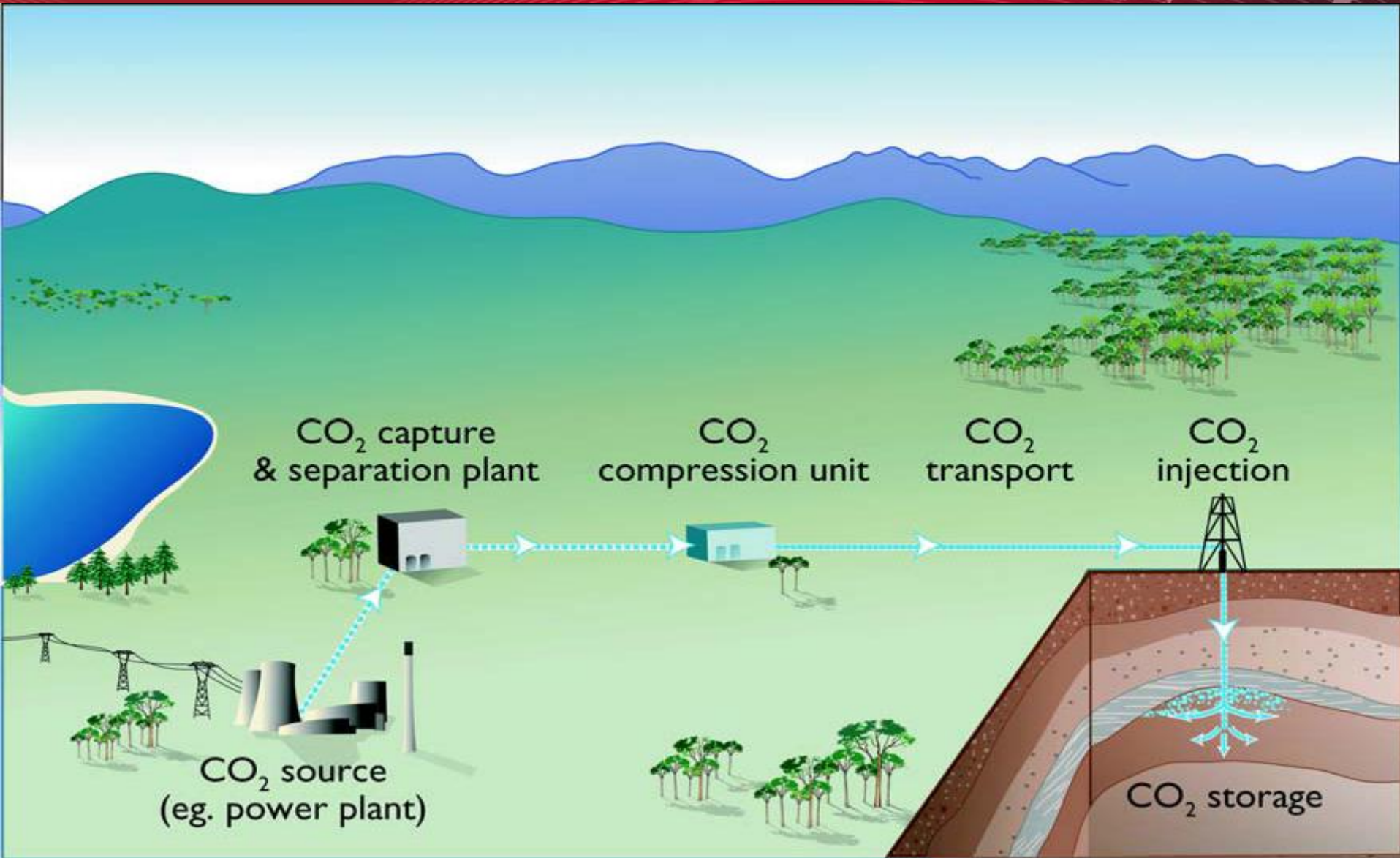
(definition by *OPGGS Bill 2008*)

The Greenhouse Effect

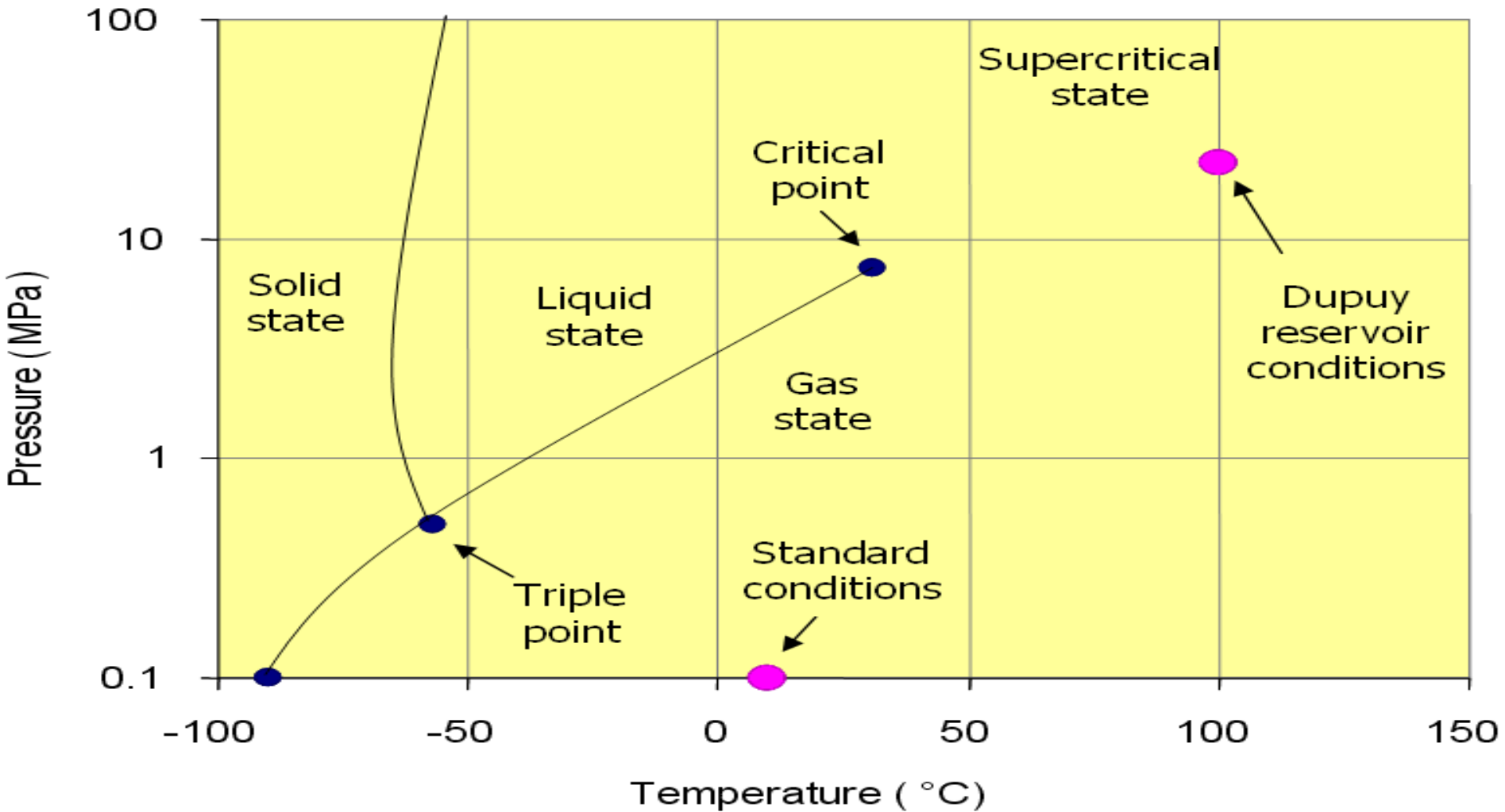
The greenhouse effect



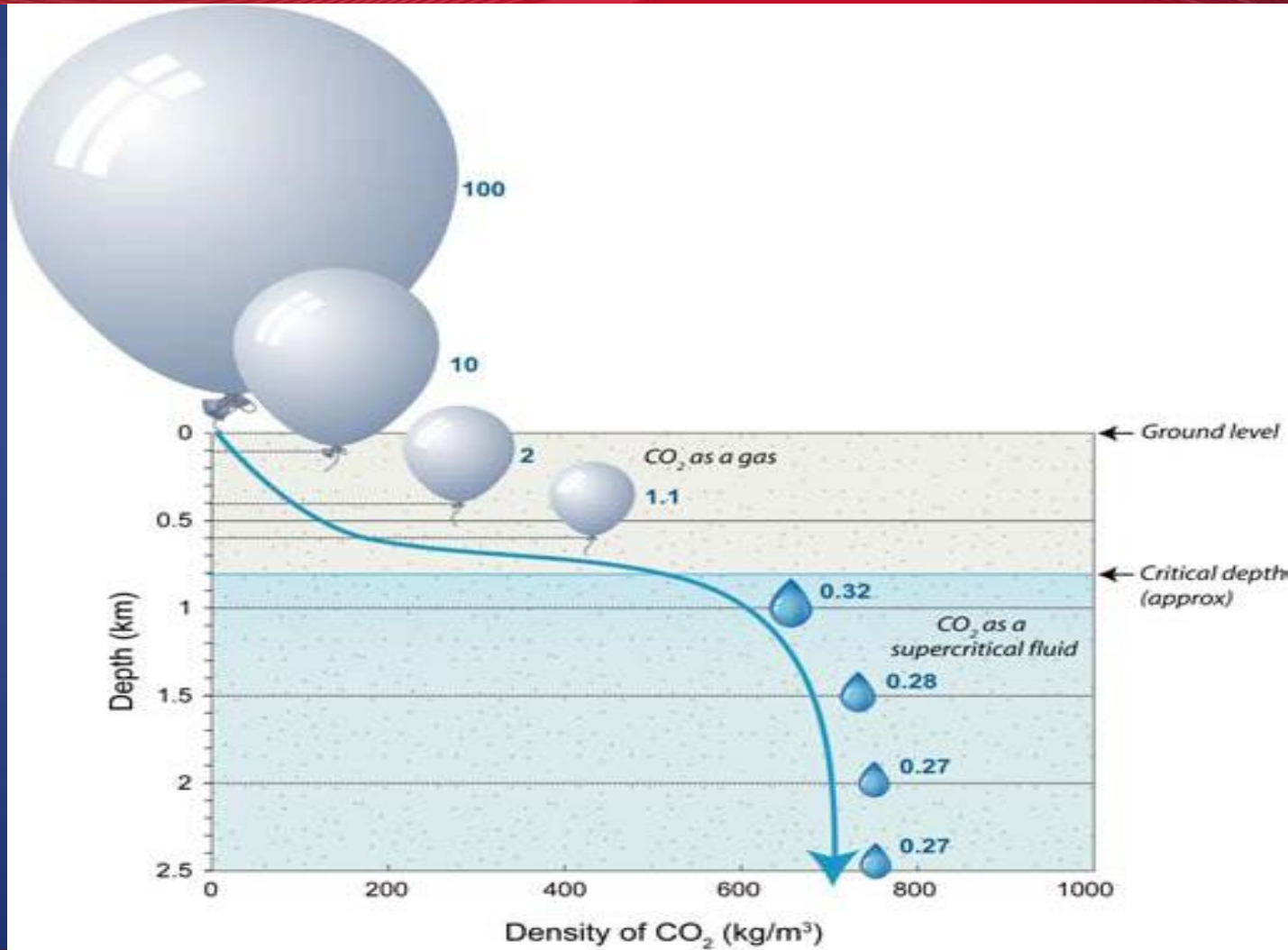
CO₂ Geological Storage Process



CO₂ Phase Diagram



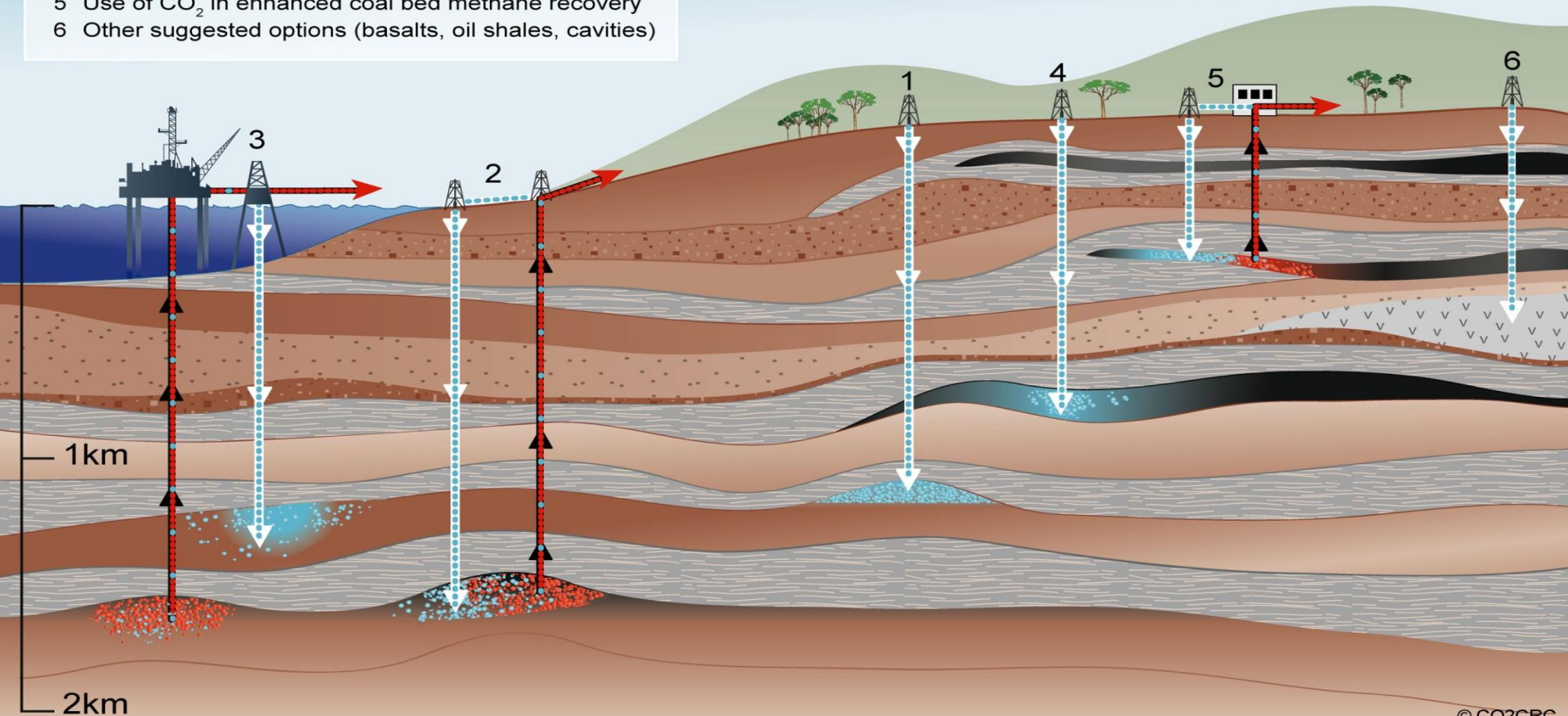
CO₂ Density vs. Depth



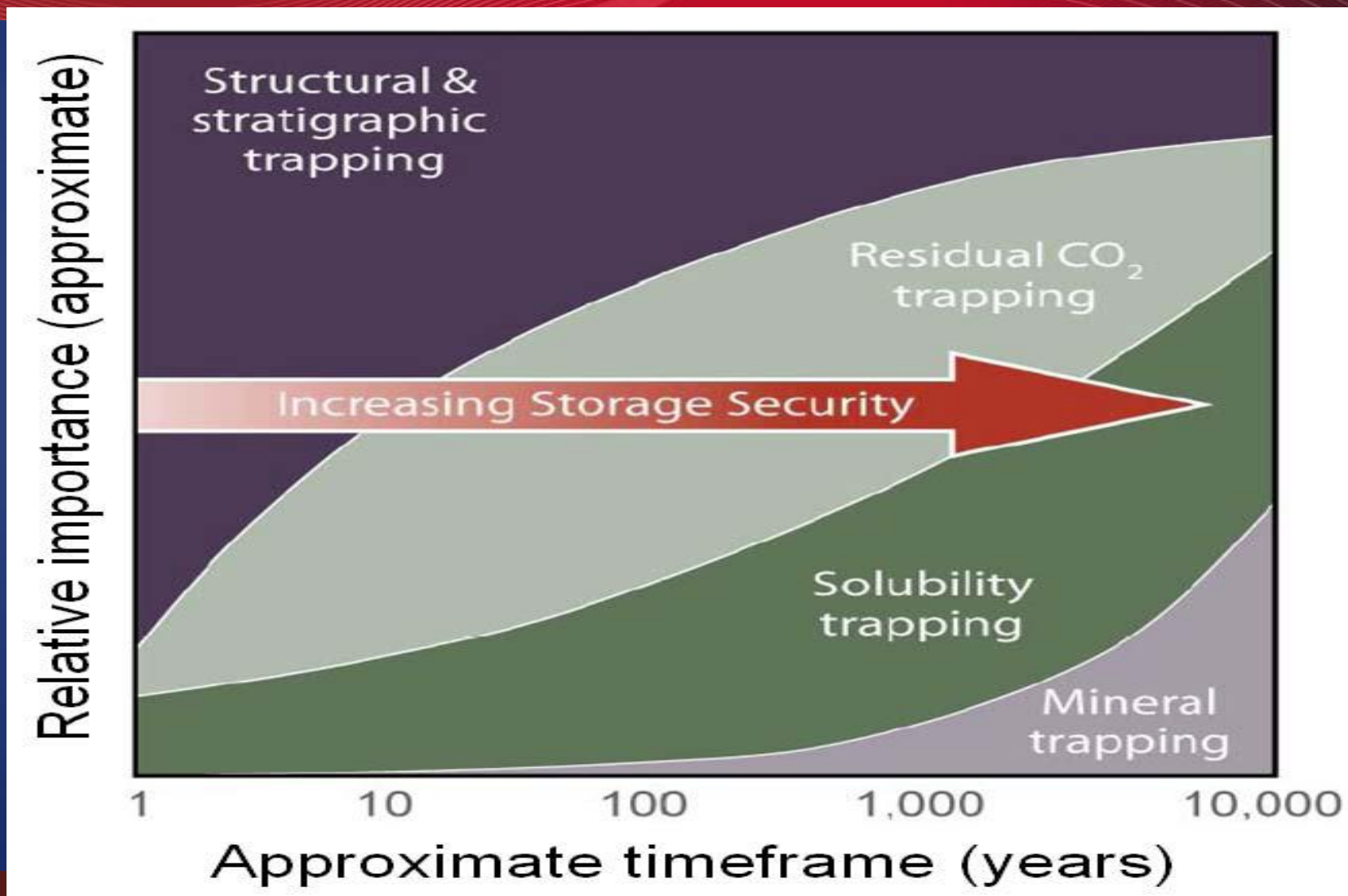
CO₂ Geological Storage Options

Geological Storage Options for CO₂

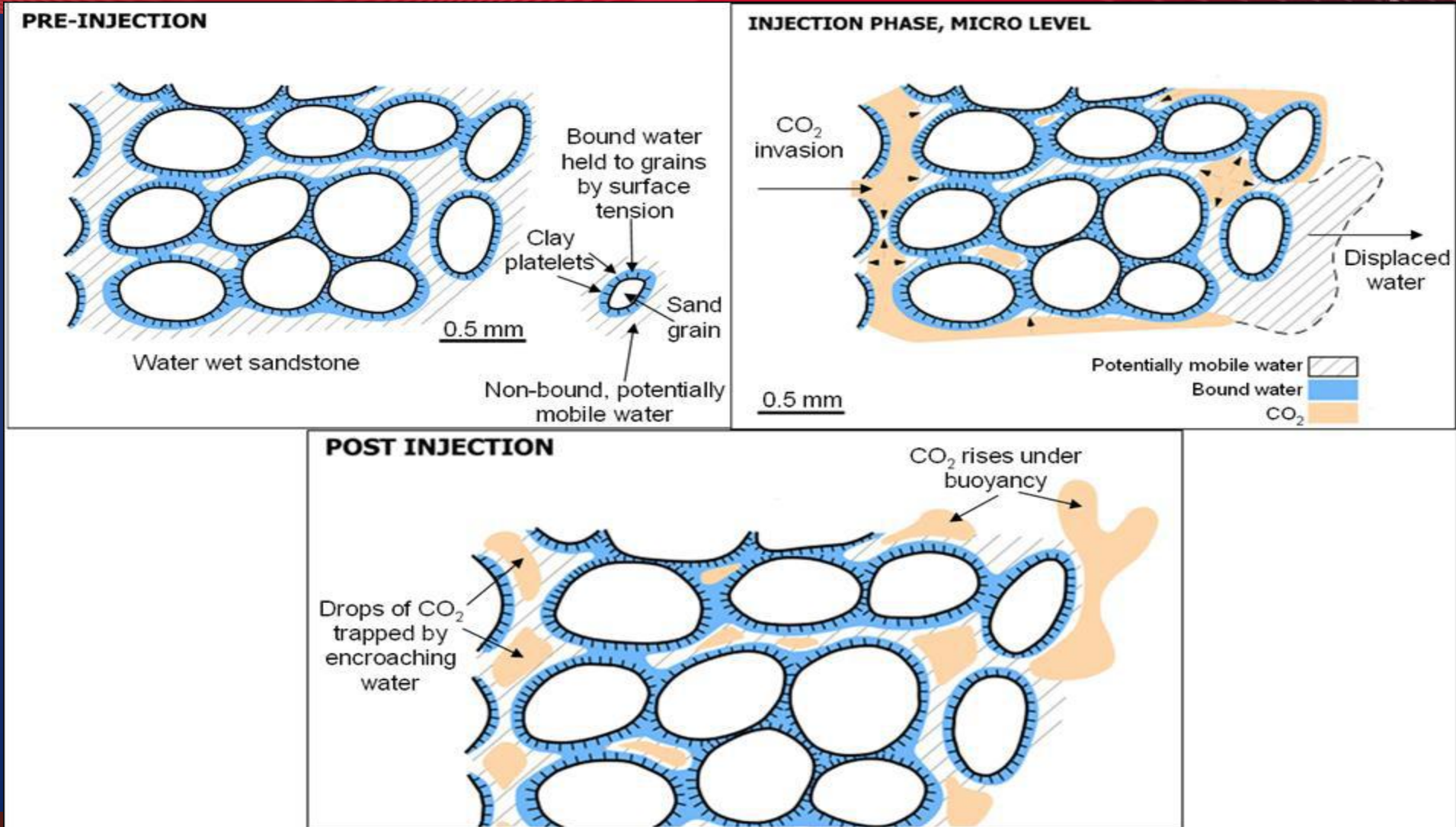
- 1 Depleted oil and gas reservoirs
- 2 Use of CO₂ in enhanced oil recovery
- 3 Deep unused saline water-saturated reservoir rocks
- 4 Deep unmineable coal seams
- 5 Use of CO₂ in enhanced coal bed methane recovery
- 6 Other suggested options (basalts, oil shales, cavities)



Relative Importance of CO₂ Trapping Mechanisms in Saline Aquifer

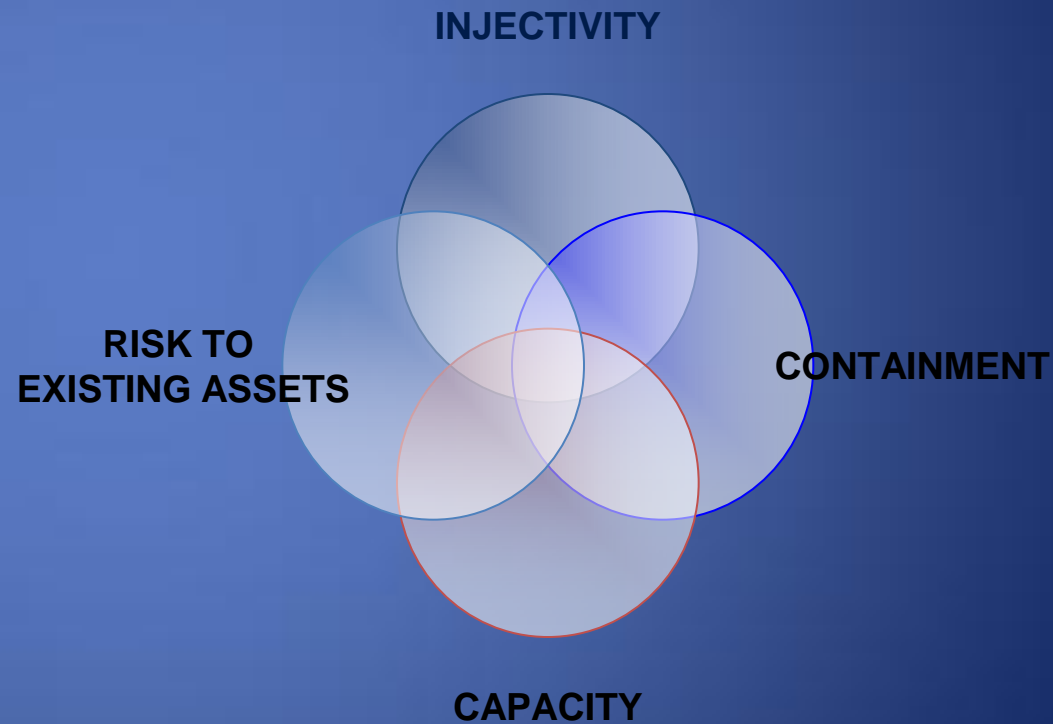


Pore-Scale Fluid Flow Showing Solution and Residual Trapping Mechanisms

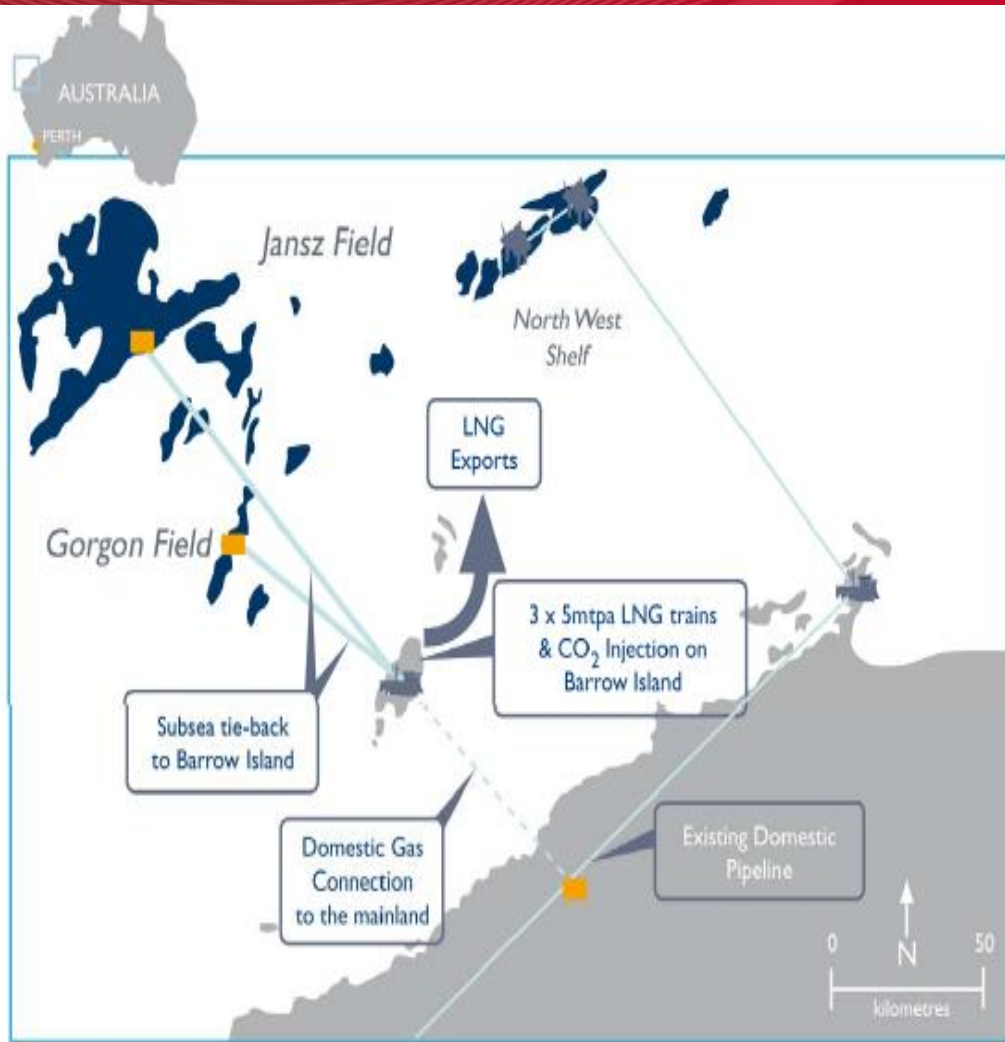


CO₂ Sequestration Site Selection Criteria

- **Storage Capacity:** Can the reservoir/aquifer store the full volume of CO₂ to be injected
- **Injectivity:** Can we inject the CO₂ into reservoir?
- **Containment Risks:** Will CO₂ remain in the reservoir?
- **Risks to Other Assets**
Will there be risks to other assets (water, HC, geothermal etc) following injection of CO₂

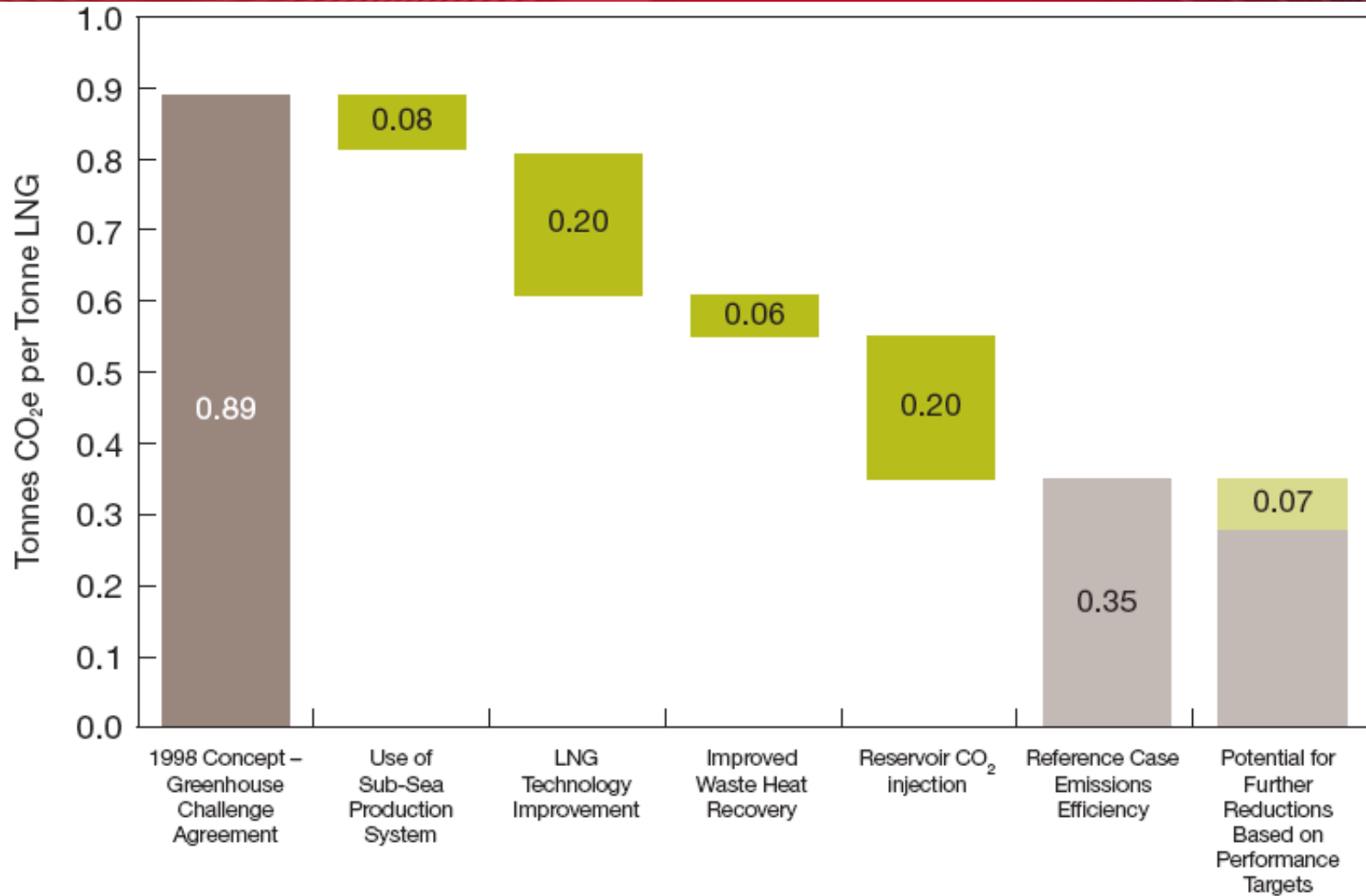


Gorgon CO₂ Disposal Project

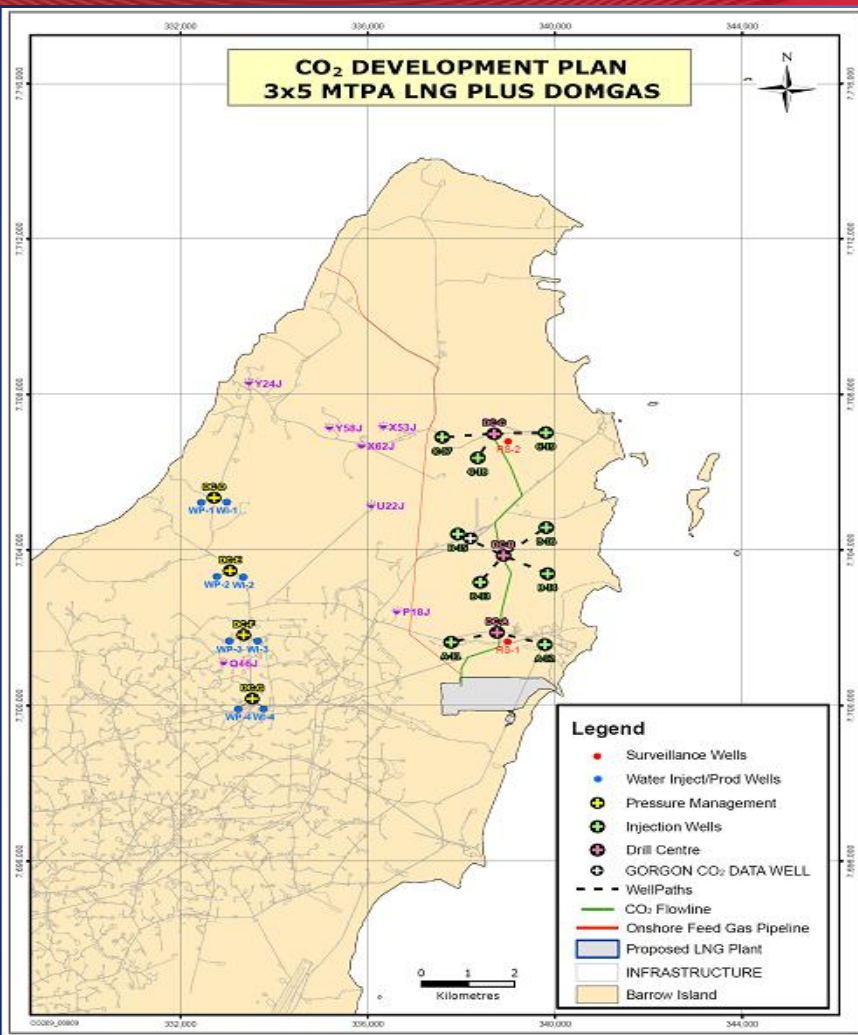


- Gas Produced from subsea wells from Gorgon and Jansz fields (> 2 Bcf/d gross), total CO₂ 1.6-2.4 tcf
- 3x5 MTPA LNG + Domgas (300 TJ/D)
- CO₂ content: Gorgon 14%, Jansz: <1%
- CO₂ separated, compressed and injected into Dupuy Formation underneath Barrow Island
- Project underway
- First LNG scheduled 2014
- Future expansion opportunities under review

Gorgon Project Greenhouse Emissions Efficiency Improvements

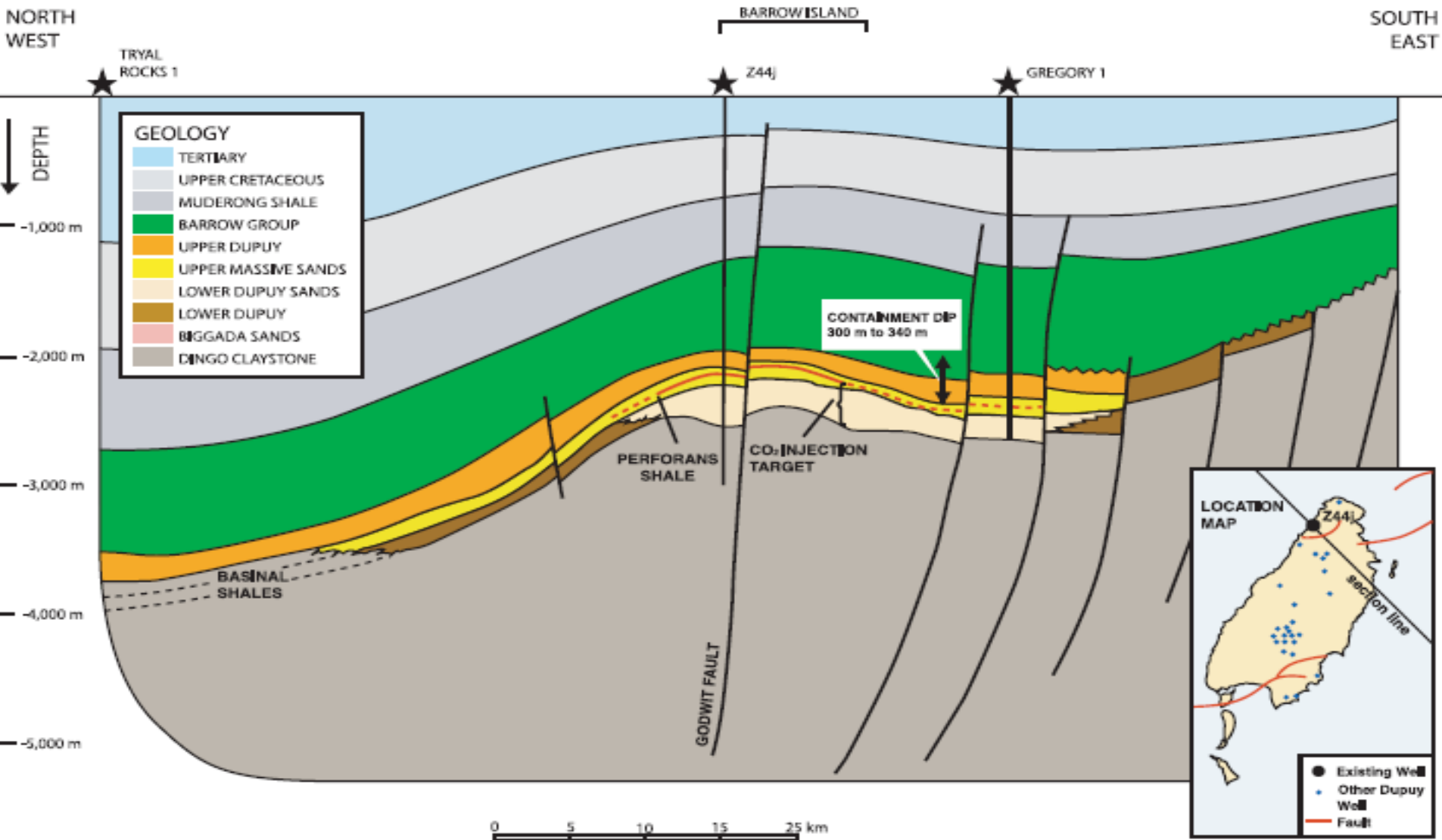


Reference Case CO₂ Development Plan

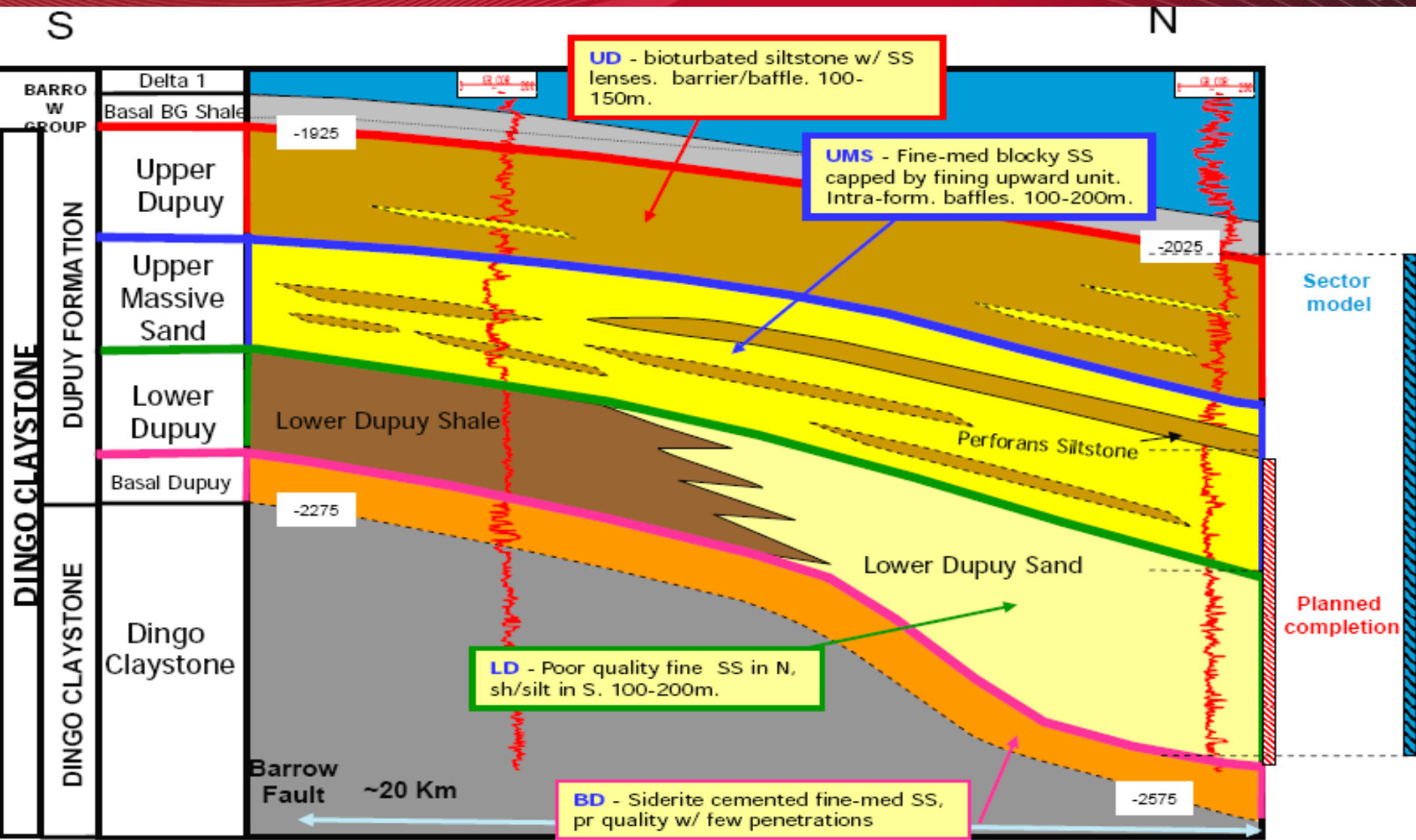


- Volume of CO₂ to be injected: 1.6-2.4 tcf (80 – 130 million tonnes)
- Peak stream day rate: 220 MMscf/d
- 9 injection wells from 3 drilling centres (up to 18 wells)
- 4 surveillance wells – 2 initially, plus 2 later
- 4 pressure management wells (4 water producing wells + 2 water injection wells)

Barrow Island NW-SE Cross Section



Barrow Island South – North Cross Section



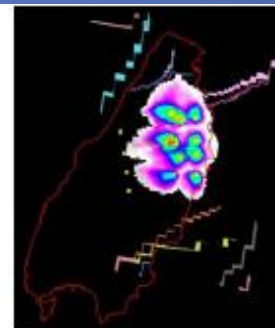
Reference Case CO₂ Plume



Year 5



Year 10



Year 65



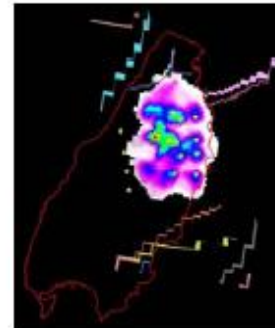
Year 100



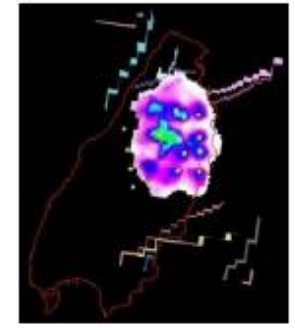
Year 20



Year 40



Year 500

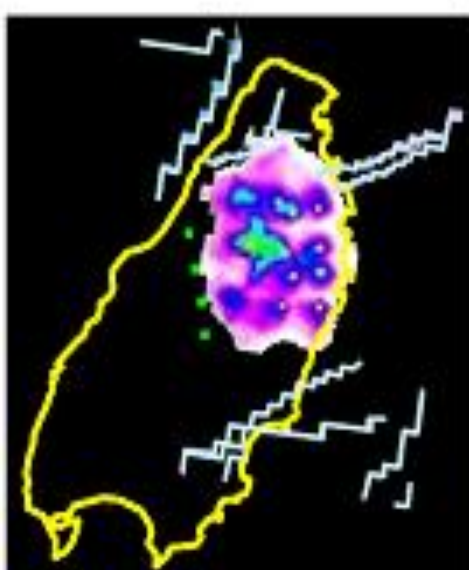


Year 1000

Net CO₂ Thickness: $\Sigma S_g \cdot \Phi \cdot h$ 0  14m

Year 1000 plumes

Net CO₂ Thickness: $\Sigma S_g \cdot \Phi \cdot h$ 0  14m



Reference HML



High Injectivity HHL



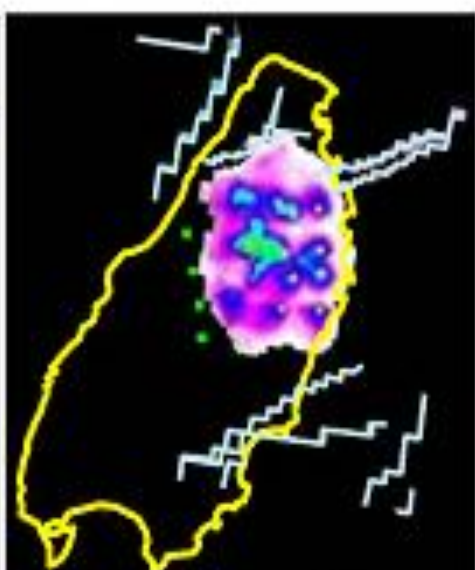
LLL



HLL



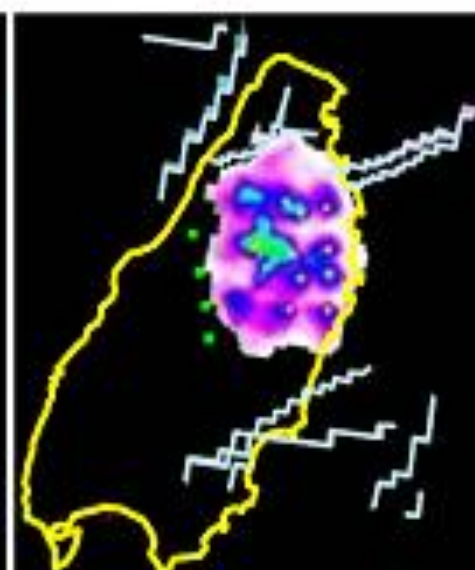
Low Porosity



High Porosity



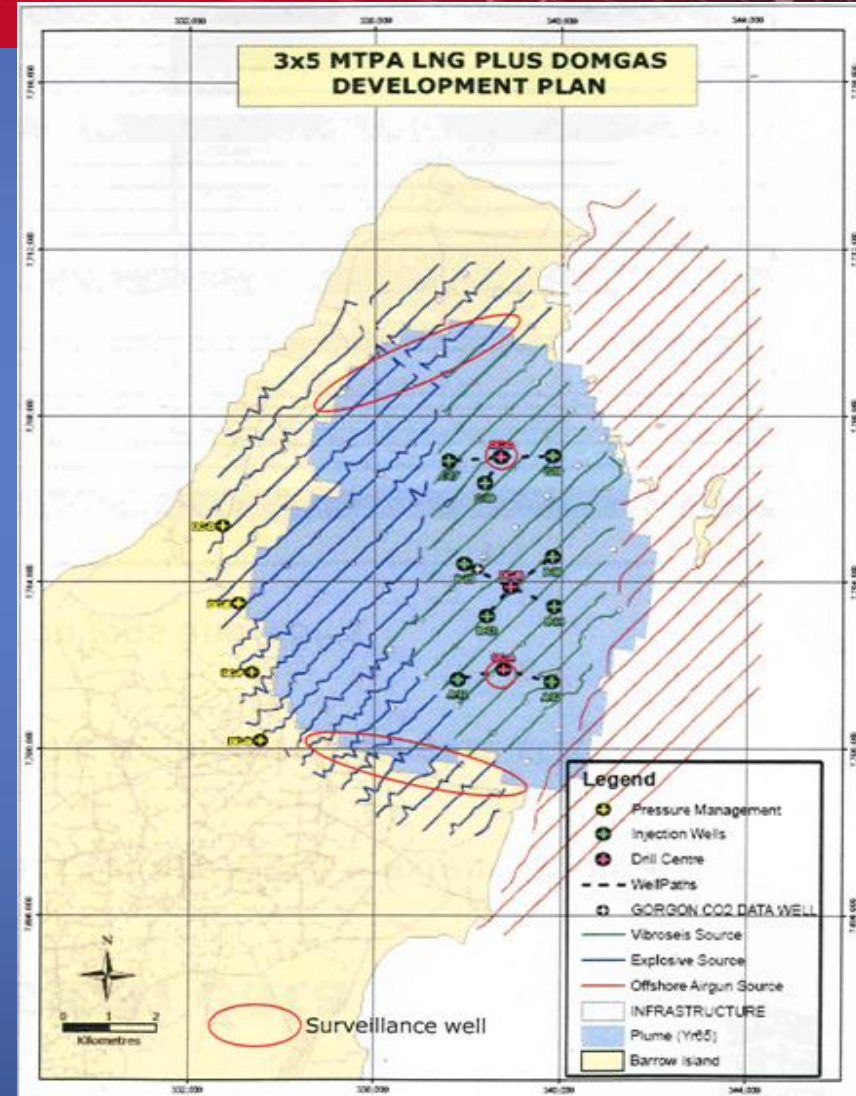
Vertical Variogram
Half



Vertical Variogram
Double

Monitoring Plans

- CO₂ Injection & Pressure Management Wells
 - Well head pressure and flow rate
 - Continuous down-hole pressure
 - PLT & casing/cement integrity logs
- Surveillance Wells – Vertical Distribution and Volumetric Calculation
 - Continuous downhole pressure (Barrow Gp)
 - Saturation & casing/cement integrity logs
 - Vertical Seismic Profiling (VSP)
- 4D Seismic – Lateral extent and broad vertical distribution
 - 3D baseline survey
 - Repeat 2D & 3D surveys
- Soil Gas – Verification
 - Soil gas flux sampling over the 3D seismic source grid and at potential near-surface seepage points
- Surface – Safety & Environment
 - Pressure sensors and CO₂ detection equipment within compression and pipeline facilities



Collie Hub Project Background

- Geodisk Program 1998
- 2003 South Perth Basin Geosequestration Study
- 2007 CO2CRC Study & Recommendations (Harvey Ridge CCS Potential)
- Schlumberger Study 2010
- Collie Hub –one of 4 Flagships Projects 2011

Collie Hub Partners

- Department of Mines and Petroleum
- Perdaman Chemicals and Fertilisers
- Verve Energy
- Griffin Energy
- Wesfarmers Premier Coal
- BHP Billiton Worsley Alumina
- Alcoa Australia
- research partnership:
 - WA:ERA (Western Australian Energy Research Alliance)
a collaborative arrangement between UWA, Curtin University and the CSIRO

The Concept of Collie Hub CCS

- Integrated industrial CO₂ geosequestration system
- Storage within an identified area
- Red mud sequestration 300,000 + tpa (Alcoa)
- 2.4 mtpa Perdaman CO₂
- Potential for up to 7 mtpa for future power generation



Red Mud CO₂ Sequestration

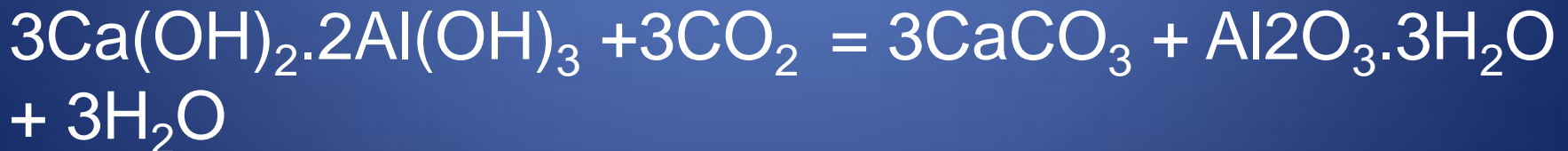
- Sodium Hydroxide converted to carbonate and bicarbonate



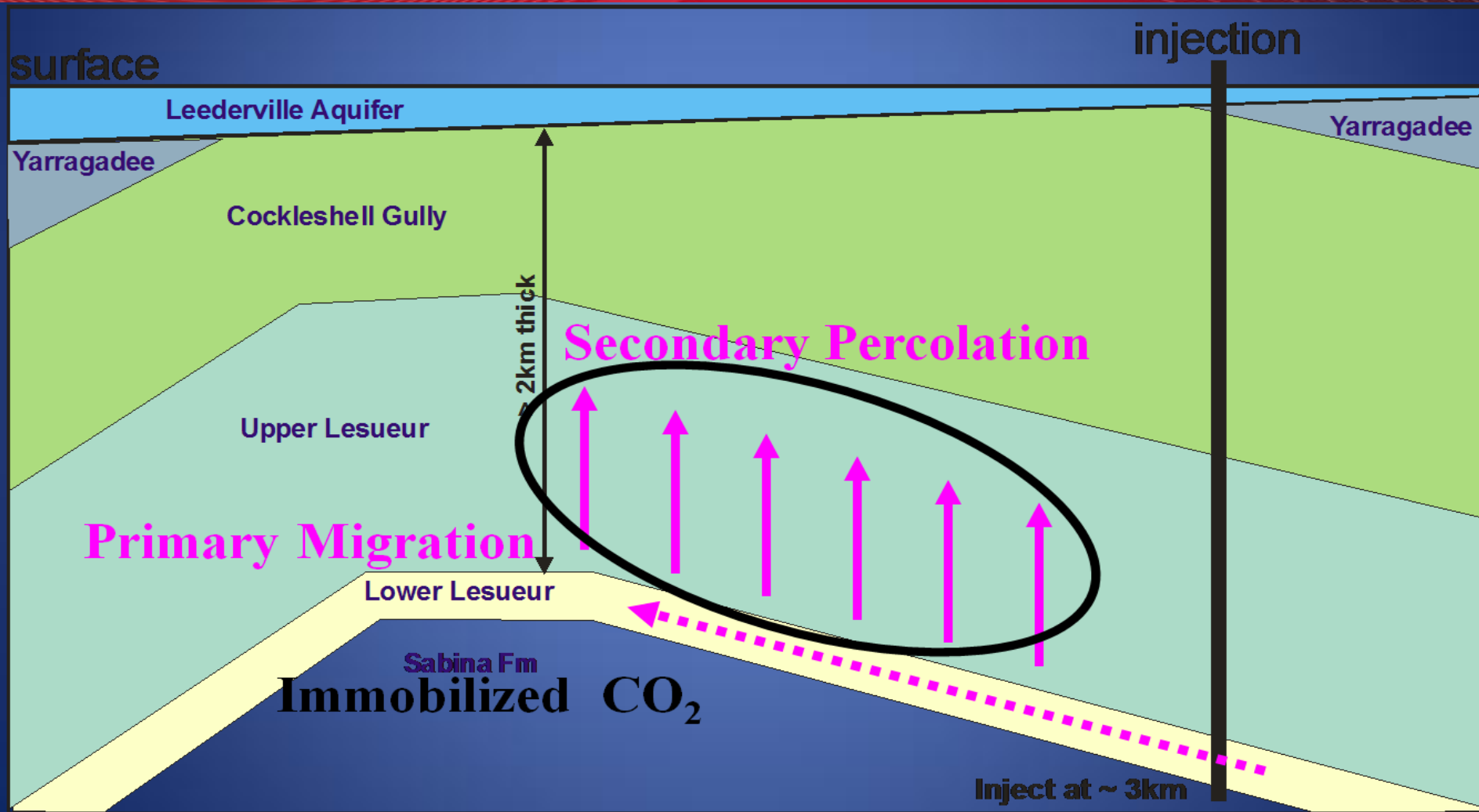
- Alumina precipitated as sodium alumina carbonate



- TCA6 converted to calcite and gibbsite



The Lower Leuseur CCS Concept



Collie Hub –The Largest Unconventional CCS Proposal

- Established the Lesueur Community Consultative Group (LCCG) by Minister Moore
- Baseline Seismic Survey
- Multi-purpose Stratigraphy Well
- Enabling Case:
 - Kwinana CO₂ for Red Mud Sequestration +
 - Lesueur Formation Geological Storage Trial
- Business Case: CO₂ from Perdaman
- Fully Commercial Case: Power Generation CO₂

Summary

- CO₂ Geological Storage
 - ✓ CO₂ Phase Behaviour
 - ✓ Storage Options
 - ✓ Trapping Mechanisms
- Gorgon CO₂ Disposal – The Largest in the World
- Collie Hub – The Largest Unconventional CCS Proposal

Thank You

