PTRC Weyburn EOR/CCS Project

Risk Assessment Update

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Melbourne, Australia
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Outline

- Background and approach
- Application to PTRC Weyburn project
  - Reservoir (Geosphere) risk assessment
  - Environmental (Biosphere) risk assessment
  - Future stakeholder engagement program
Risk assessment methodology developed as part of Geodisc program of the Petroleum CRC

APPEA paper (Bowden and Rigg) on assessing risk in storage projects

Application of methodology with CO2CRC to several storage projects (e.g. Gorgon, Otway Basin PP, Denison Trough, Gippsland Basin, In Salah)

Apply method to Weyburn EOR Project and expand methodology to include environmental and social risk
Approach

- The approach utilises the RISQUE method (Bowden et al, 2001)
- Risk = Likelihood x Consequence
- Systematic process that uses a formal group of experts to provide judgements on likelihoods and consequences
- Produce outputs that can be used to assist decisions
Application to PTRC Weyburn Project
PTRC Weyburn risk assessment objectives

- Apply CO2CRC risk assessment to PTRC Weyburn
- Benchmarking
- Further develop methodology
- Expand the risk assessment from purely technical into the environmental and stakeholder domains
- Provide guidance to future research
- Assist the process of gaining stakeholder support
Process towards stakeholder acceptance

Reservoir (Geosphere) risk assessment
- Containment
- Effectiveness
- CO₂ risk management

Skills needed:
Geophysics, reservoir engineering, hydrochemistry, geotechnical, hydrogeology, operations, gas transport, natural analogues

Environmental (Biosphere) risk assessment
- Environmental risk management
- Environmental asset protection

Skills needed:
Biology, ecology, hydrology, social impact assessment, soil science, agricultural science, hydrogeology, operations, gas transport, natural analogues, engineering, economics, cultural heritage

Community outreach program
- Local and regional communities
- Regulators
- Shareholders
- International community

Skills needed:
Community education, public relations, geological storage technology

Stakeholder acceptance

Stakeholder communication
1. Reservoir (Geosphere) risk assessment

- Is the project going to meet CO₂ storage objectives?
  - Accept the planned storage volumes? - Effectiveness
  - Retain 99% of injected CO₂ in geosphere for 1,000 years? - Containment

- What are the risk events that could initiate CO₂ movement from the geosphere?

- What are the key pathways for movement from the geosphere?

- What are the potential rates of CO₂ escape from the geosphere?
Comparison of event containment risk

- Risk Quotient CL95%
- Risk Quotient CL80%
- Risk Quotient CL50%
- Target single event Containment Risk
- Target Project Containment Risk

- Seals - Modeled loss
- Fract - Modeled loss
- Migrat - Modeled loss
- Wells - Modeled loss
- EOR - Through faults
- EOR - Minor faults network
- Nat - Natural seismicity - reactivation
- Nat - Natural seismicity - existing fracs
- Nat - Natural seismicity - new fracs
- EOR - Induced chemical var - reactivation fracs
- EOR - Induced chemical var - existing fracs
- EOR - Induced temperature var - new fracs
- EOR - Induced temperature var - existing fracs
- Nat - Salt dissolution
- Nat - Natural seismicity
- Wells - Old wells - micro annuli
- Wells - Old wells - micro annuli
- Wells - New wells - micro annuli
- Wells - New wells - micro annuli
- Wells - Well casing corrosion
- Wells - Undetected faulty wells
- Wells - Old old wells outside Weyburn property
- Wells - Casing cementing - old wells

Total containment risk
Containment risk assessment conclusions

- The process has identified gaps and uncertainties in information relating to the risks associated with CO$_2$ release to the biosphere.
- The current outputs of the risk model are only a guide to the risk profile of the project.
- Outputs useful to direct the focus for future studies.
- Need to incorporate the estimates of CO$_2$ release to the biosphere into an appropriate assessment of the potential environmental impacts on the biosphere.
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2. Environmental (Biosphere) risk assessment

- Typical EES approach – what are the predicted and potential effects on the wider environment
- Which environmental and community assets are valued by the community?
- What are the community concerns?
- Where and how much CO$_2$ could enter the biosphere?
- What are the highest risk pathways?
- Which assets are at most risk?
- Which Biosphere components are the main contributors to the risk?
Pathways and assets

**BIOSPHERE**
- Souris River
- Lakes
- Surface soils
- Water supply wells
- Fracture systems
- Weyburn Valley Aquifer
- Tertiary / Cretaceous aquifer
- ~50 m depth

**GEOSPHERE**
- Wells
- Faults
- Reservoir store of CO₂
- Reservoir seal
- ~1500 m depth
- Quaternary aquifers and aquitards
- Fracture systems
- Faults
## Risk identification

- **Cause and effect process**
- **Likelihoods – for each step**
- **Consequences – Consequences table**

<table>
<thead>
<tr>
<th>CONSEQUENCE LEVEL</th>
<th>Negligible</th>
<th>Minor</th>
<th>Moderate</th>
<th>Major</th>
<th>Extreme</th>
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<tr>
<td>PROPERTY / INFRASTRUCTURE</td>
<td>Cost to repair, replace, remediate (and lost revenues)</td>
<td>Approximate range from $0 to $0.1 million.</td>
<td>Approximate range from $0.1 to $1 million.</td>
<td>Approximate range from $1 to $10 million.</td>
<td>Approximate range from $10 to $100 million.</td>
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<td>ENVIRONMENTAL</td>
<td>Ecosystem Function (need to consider resilience and resistance)</td>
<td>Alteration or disturbance to ecosystem within natural variability. Ecosystem interactions may have changed but it is unlikely that there would be any detectable change outside natural variation / occurrence.</td>
<td>Measurable changes to the ecosystem components without a major change in function (no loss of components or introduction of new species that affects ecosystem function).</td>
<td>Measurable changes to the ecosystem components without a major change in function (no loss of components or introduction of new species that affects ecosystem function).</td>
<td>Measurable changes to the ecosystem components with a major change in function. Recovery (ie within historic natural variability) in 3 to 10 years.</td>
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<tr>
<td></td>
<td>Habitat, communities and / or assemblages</td>
<td>Alteration or disturbance to habitat within natural variability. Less than 1% of the area of habitat affected or removed.</td>
<td>1 to 5% of the area of habitat affected in a major way or removed. Re-establishment in less than 1 year (relative to component seasonality).</td>
<td>5 to 30% of the area of habitat affected in a major way or removed. Re-establishment in 1 to 2 years.</td>
<td>30 to 90% of the area of habitat affected in a major way or removed. Re-establishment in 3 to 10 years.</td>
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<td>Species and / or groups of species (including protected species)</td>
<td>Population size or behaviour may have changed but it is unlikely that there would be any detectable change outside natural variation / occurrence.</td>
<td>Detectable change to population size and / or behaviour, with no detectable impact on population viability (recruitment, breeding, recovery) or dynamics. Recovery in less than 1 year.</td>
<td>Detectable change to population size and / or behaviour, with no impact on population viability (recruitment, breeding, recovery) or dynamics. Recovery in 1 to 2 years.</td>
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<td>Initiating event</td>
<td>Pathway to biosphere</td>
<td>Likelihood of over 1,000 years</td>
<td>Affected biosphere component</td>
<td>Specific asset</td>
<td>Impact on asset</td>
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<td>Groundwater</td>
<td>K/T aquifer</td>
<td>pH change</td>
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<td>Old wells outside Weyburn</td>
<td>Micro annuli</td>
<td>5.4772</td>
<td>Soils</td>
<td>Soil layer</td>
<td>Soil water PH change</td>
</tr>
</tbody>
</table>
Biosphere risk assessment outputs

- Use to:
  - Progressively modify project design and research planning
  - Reduce overall risk of project
  - Communicate risk to wider community
  - Demonstrate level of risk to specific assets
  - Demonstrate due diligence
What are the highest risk pathways?

Initiating Events - Total Risk

- EOR - Minor faults network
- EOR - Thru faults
- EOR - Induced pressure var - reactivation fracs
- EOR - Induced pressure var - new fracs
- EOR - Induced temperature var - reactivation fracs
- EOR - Induced temperature var - new fracs
- Nat - Lateral migration
- Nat - Salt dissolution
- Nat - Natural seismicity - reactivation
- Nat - Natural seismicity - new fracs
- Nat - Natural seismicity - wells
- Wells - Old wells - micro fracs
- Wells - New wells - micro fracs
- Nat - Natural seismicity
- Wells - Old wells - micro annuli
- Wells - New wells - micro annuli
- Wells - Well casing corrosion
- Wells - Undetected faulty wells
- Wells - Cement channelling - old wells
- Wells - Old wells outside Weyburn property
### Initiation Events - Risk to Assets

<table>
<thead>
<tr>
<th>Event Description</th>
<th>Probability</th>
<th>Risk Level</th>
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<tr>
<td>Illness, injury, fatality</td>
<td>0.001</td>
<td>1</td>
</tr>
<tr>
<td>Tourism</td>
<td>0.001</td>
<td>1</td>
</tr>
<tr>
<td>Oil and gas</td>
<td>0.001</td>
<td>1</td>
</tr>
<tr>
<td>Agriculture</td>
<td>0.001</td>
<td>1</td>
</tr>
<tr>
<td>Indigenous heritage</td>
<td>0.001</td>
<td>1</td>
</tr>
<tr>
<td>Non indigenous heritage</td>
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<td>1</td>
</tr>
<tr>
<td>Amenity - sensory, perception</td>
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<td>1</td>
</tr>
<tr>
<td>Amenity - recreation</td>
<td>0.001</td>
<td>1</td>
</tr>
<tr>
<td>Species</td>
<td>0.001</td>
<td>1</td>
</tr>
<tr>
<td>Habitat, communities, assemblages</td>
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<tr>
<td>Ecosystem function</td>
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<td>Repair, replace</td>
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<tr>
<td>Target Risk Level</td>
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</tbody>
</table>
What is the impact on any asset?

Estimated frequencies of Moderate and Major consequence levels for environmental assets

- Repair, replace
- Ecosystem function
- Habitat, communities, assemblages
- Species
- Amenity - recreation
- Amenity - sensory, perception
- Non indigenous heritage
- Indigenous heritage
- Agriculture
- Oil and gas
- Tourism
- Illness, injury, fatality

Estimated frequency of Moderate consequence

Estimated frequency of Major consequence

Frequency = 1 (certain)
Which assets are most at risk?

Asset Risk Profile and Biosphere Source of risk

Risk Value

- Air
- Groundwater
- Soils
- Lakes
- Rivers
- Target Risk Level

Ecosystem function
Habitat, communities, assemblages
Species
Amenity - recreation
Amenity - sensory, perception
Non indigenous heritage
Indigenous heritage
Agriculture
Oil and gas
Tourism
Illness, injury, fatality
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- Shareholders
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Stakeholder acceptance
3. Community outreach program (Future)

- Complete the link between technical issues and community perceptions
- Program to ensure that community perceptions of risk have been properly addressed
- Community education program to provide communities with an understanding of the risks associated with CO2 storage?
- Identify and engage appropriate professional resources