Petroleum Technology Research Centre

A Decade of CCUS and Associated Research at the Weyburn Oilfield, Canada

Neil Wildgust, Chief Project Officer

August, 2012

US DOE Carbon Storage R&D Project Review Meeting

IEAGHG
WEYBURN-MIDALE
CO_2 MONITORING
AND STORAGE PROJECT

Petroleum Technology Research Centre

- ***Non-Profit Research & Development***
- ***Collaborative partnership with Industry, Government and Research Organizations***
- ***Committed to reducing environmental impacts of oil production***
  - **STEPS (EOR Centre of Excellence)**
- ***Research associated with CO_2 management***
  - **IEAGHG Weyburn –Midale CO_2 Monitoring & Storage Project**
  - **Aquistore**

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IEAGHG Weyburn-Midale CO_2 Monitoring & Storage Project (WMP) 2000 to 2012

Commercial EOR operations in Weyburn and Midale oilfields utilise anthropogenic CO_2

Over 20Mt of CO_2 injected and stored since 2000

WMP has used these sites to study technical aspects of CO_2 geological storage

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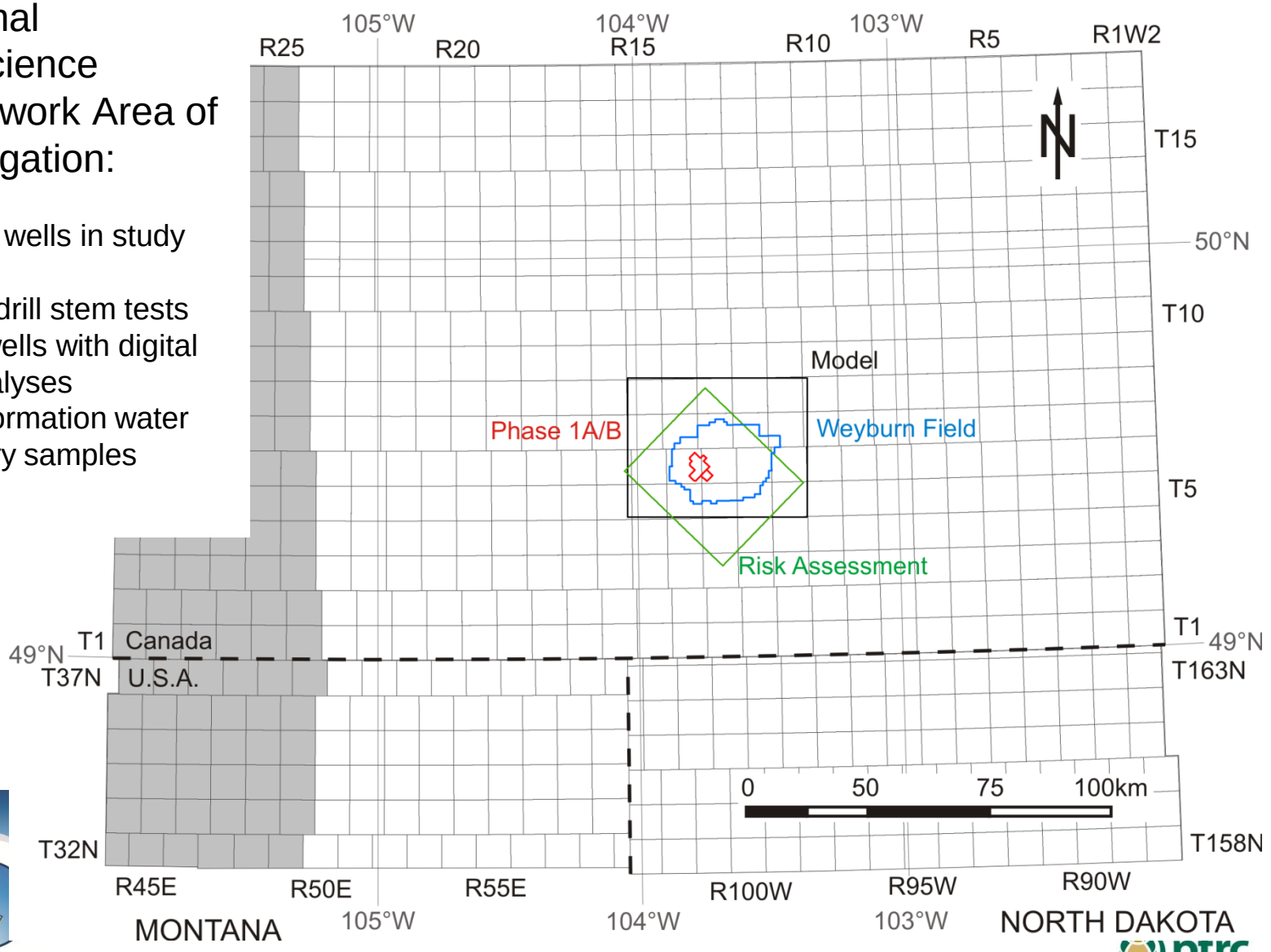
Staged Study Areas:

Regional GeoScience Framework Area of Investigation:

>30,000 wells in study area
-11,121 drill stem tests
-6,292 wells with digital core analyses
-9,207 formation water chemistry samples



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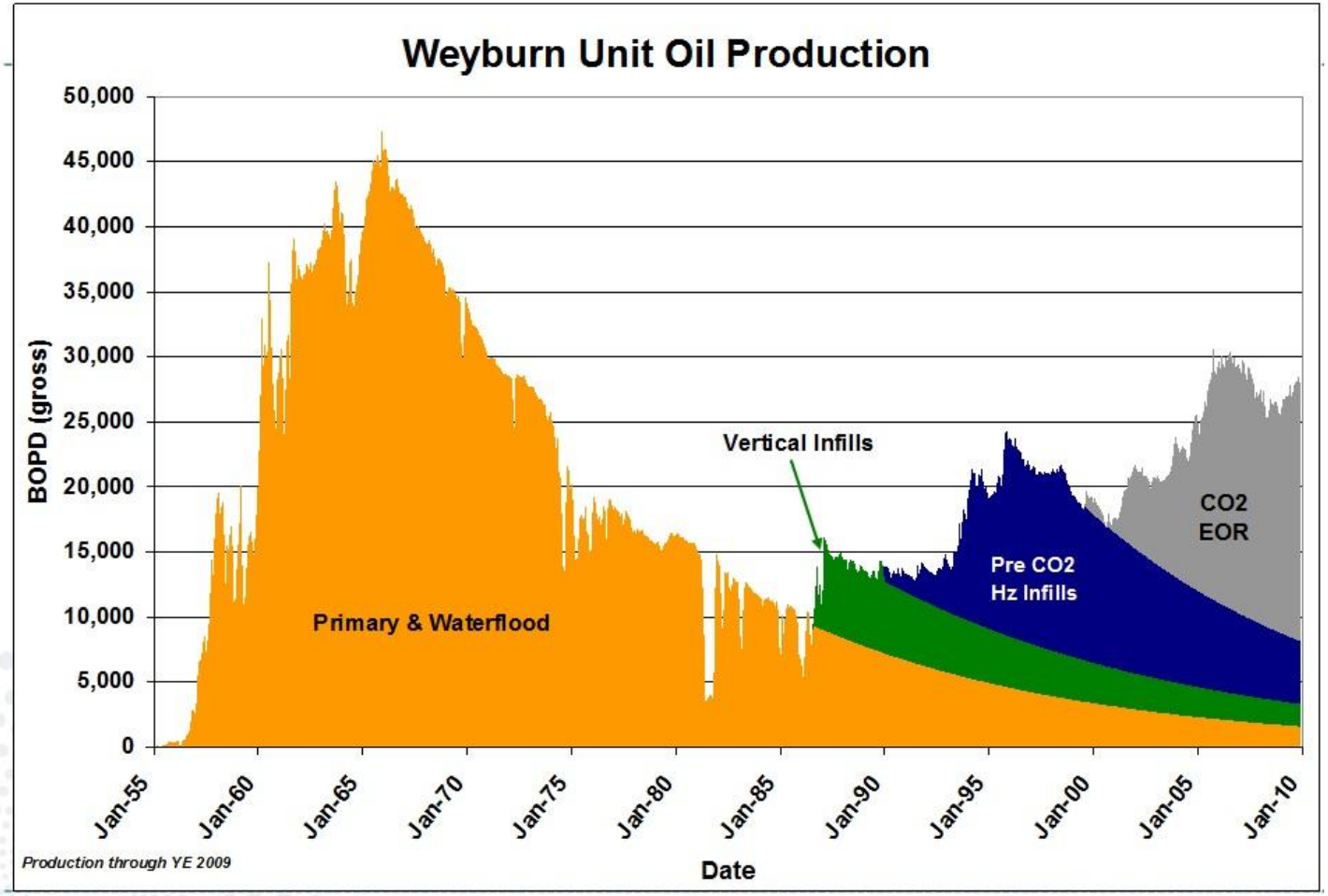

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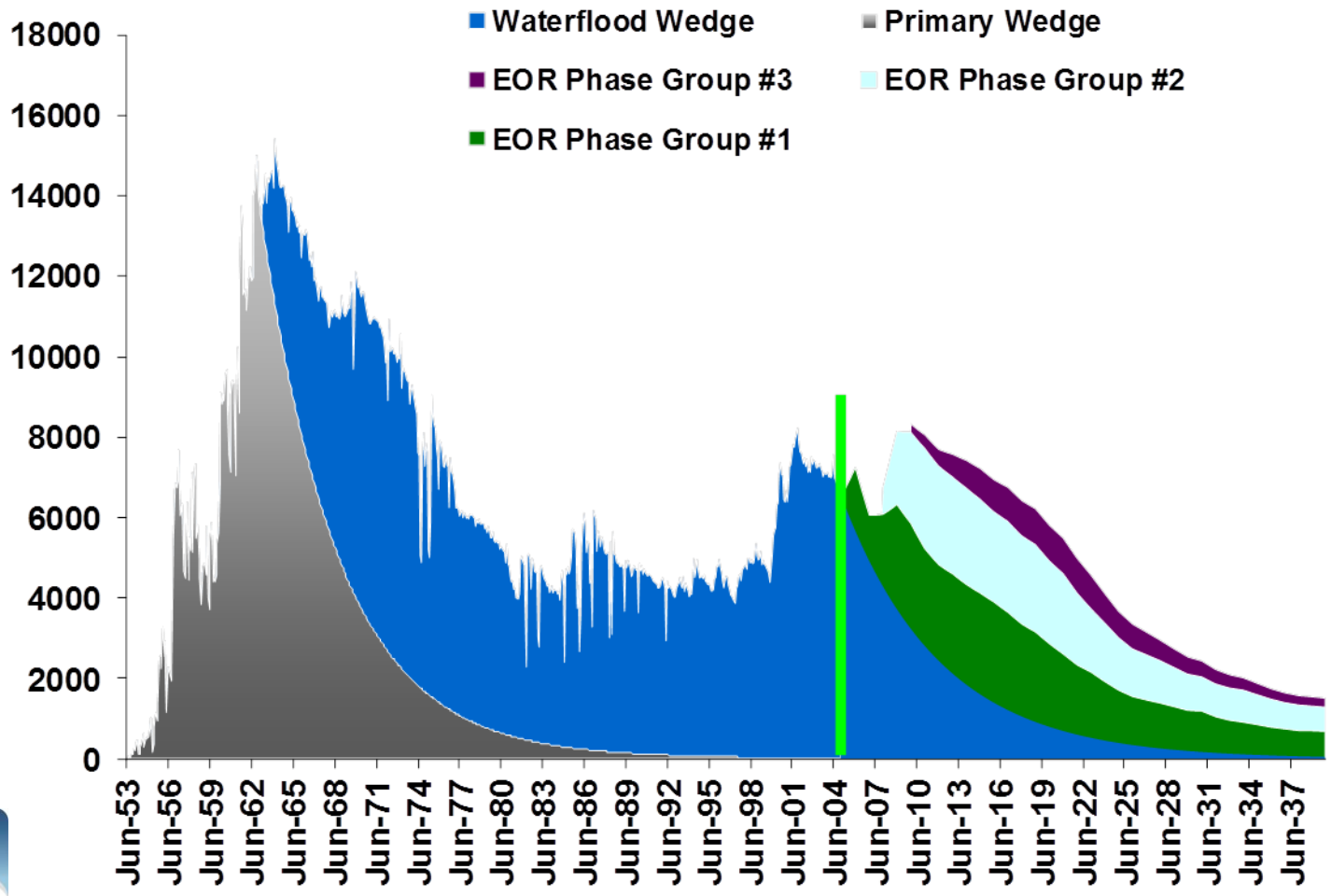
Midale Field CO2-EOR



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Best Practice Manual

Introduction

- Purpose, scope, context, background, …

Characterization

- Regional geology
- Regional hydrogeology
- Containment characterization
- Geomechanical characterization
- Geochemical characterization

Performance predictions

- CO_2 migration
- Capacity and mass partitioning
- Containment

Geochemical monitoring

- Groundwater
- Soil gas
- Reservoir fluids
- Reservoir/caprock core

Geophysical monitoring

- Geophysical char. of rock-fluid system
- Feasibility studies
- Downhole monitoring methods
- 3D seismic methods

HM and performance validation

- Prediction/measurement comparison
- Revision of Geologic Models

Well integrity

- Integrity assessment
- Design considerations
- Remediation and conversion
- Abandonment considerations
- Integrity monitoring and field testing

Risk assessment

Community outreach

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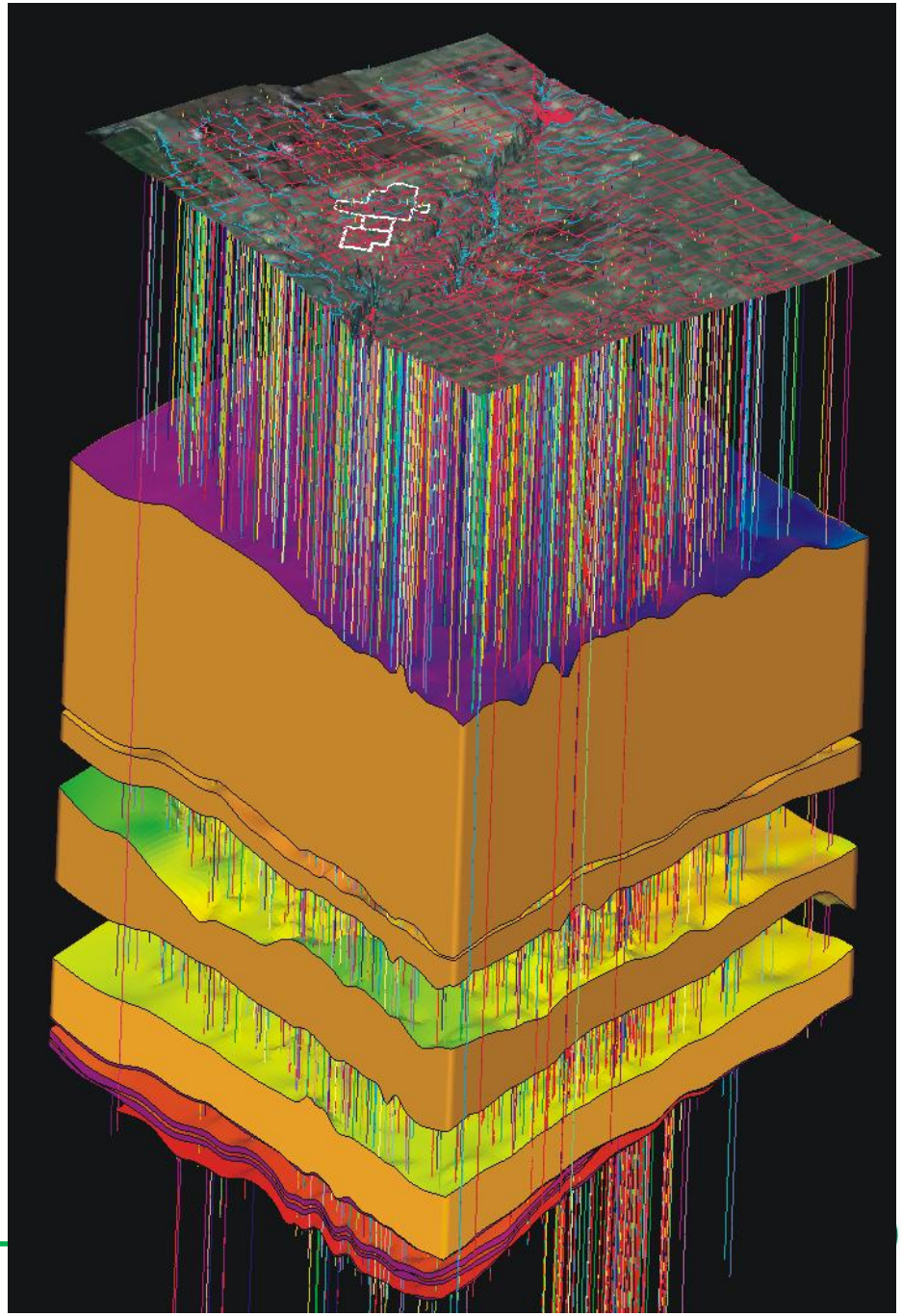
Revised Model

Was improved with:

1. More detailed aquitard characterization
2. Larger area
3. More accurate subcrop mapping
4. Increased well density (800 in area)



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Migration scenarios (Cavanagh, 2011)

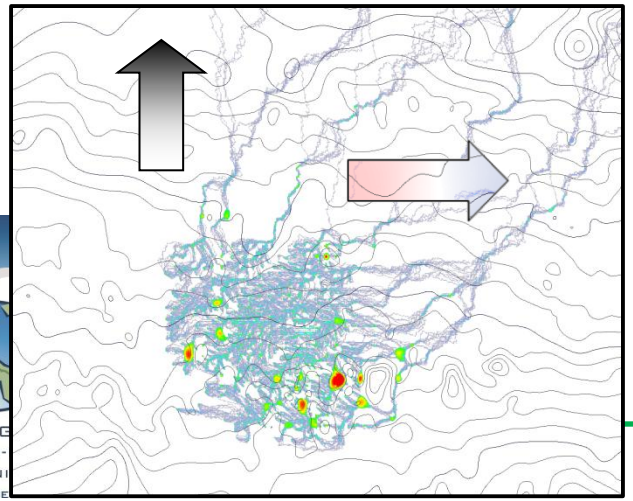
Slightly leaky wells: 1 micron

Containment: Jurassic aquifer

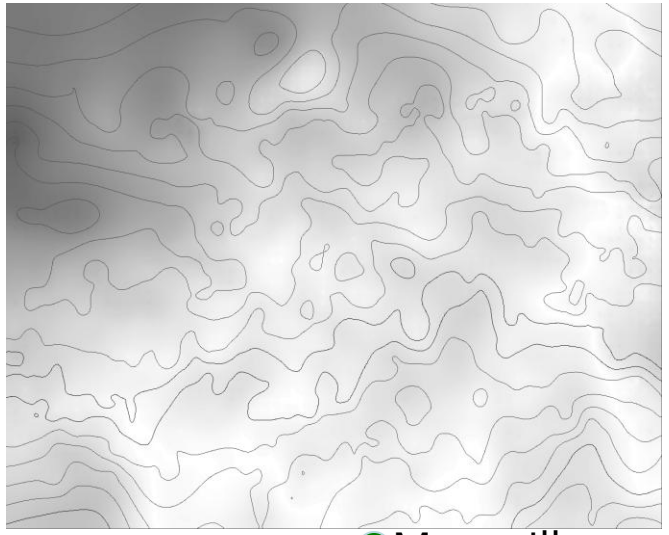
Newcastle: ---
Mannville: ---
Jurassic: *1.4 Mt*

Newcastle ---
Mannville ---
Jurassic *20 largest pools, 1.3 Mt*

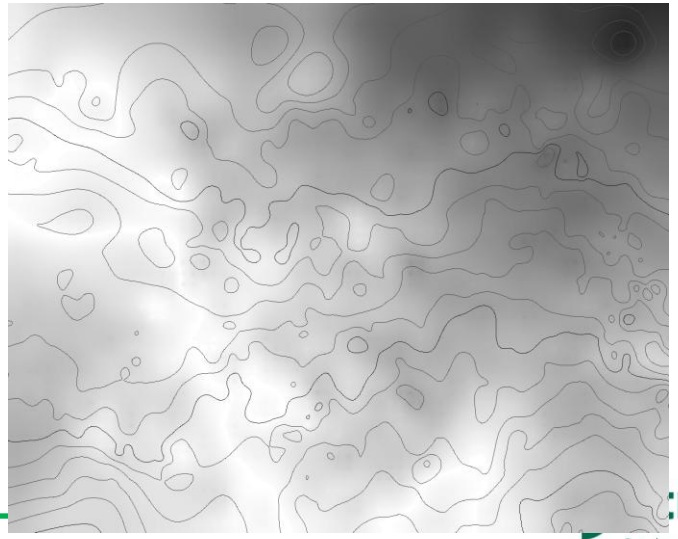
- Jurassic: small pools, migrates NE



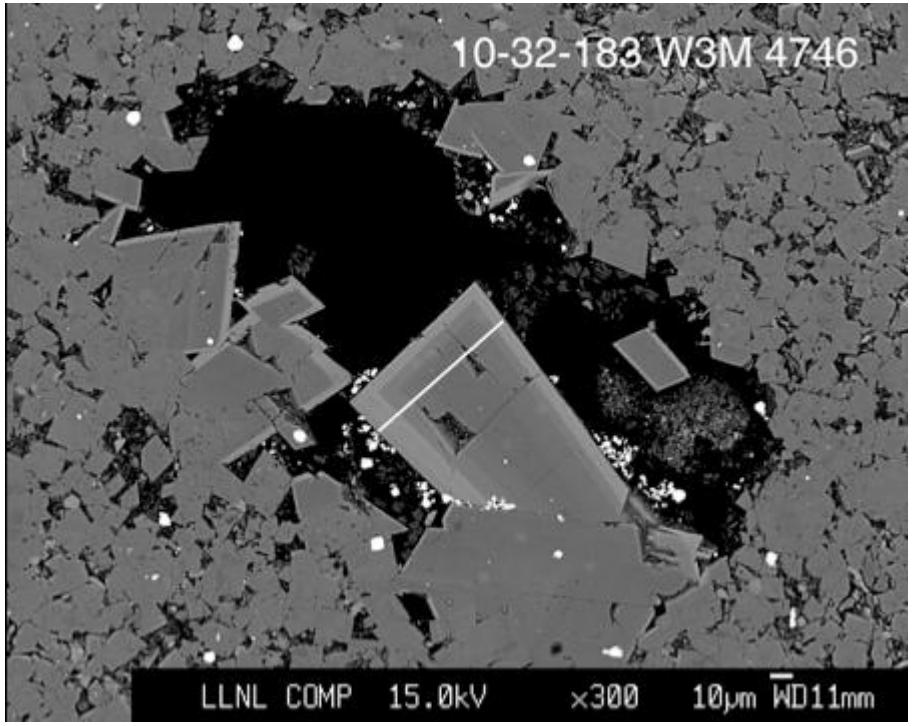
Newcastle



Mannville



Natural Analogue Study



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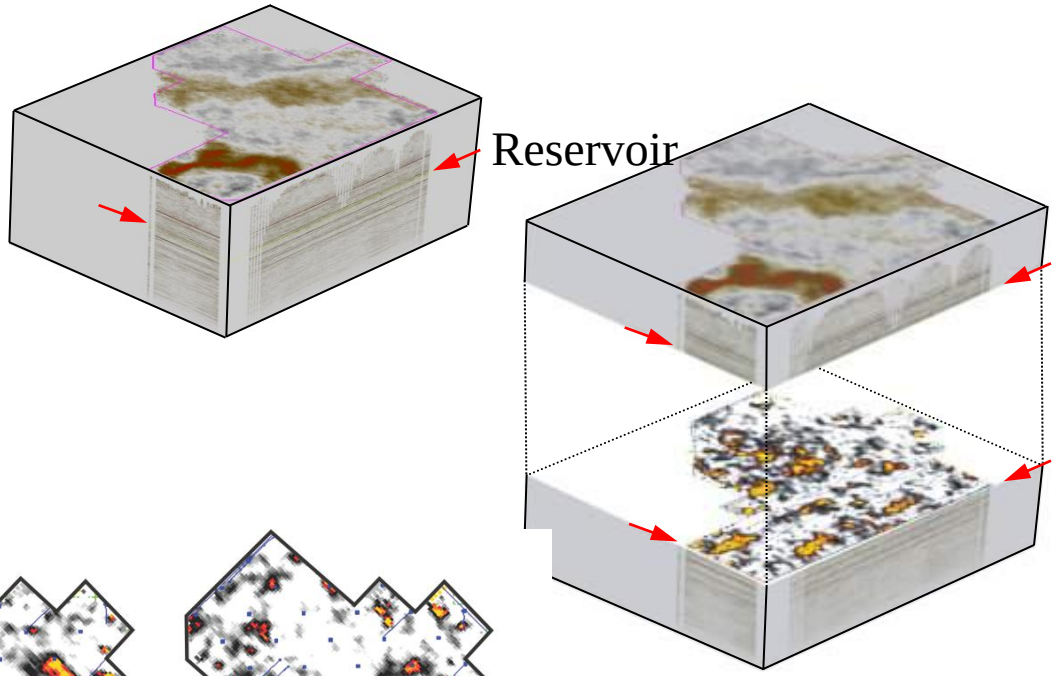
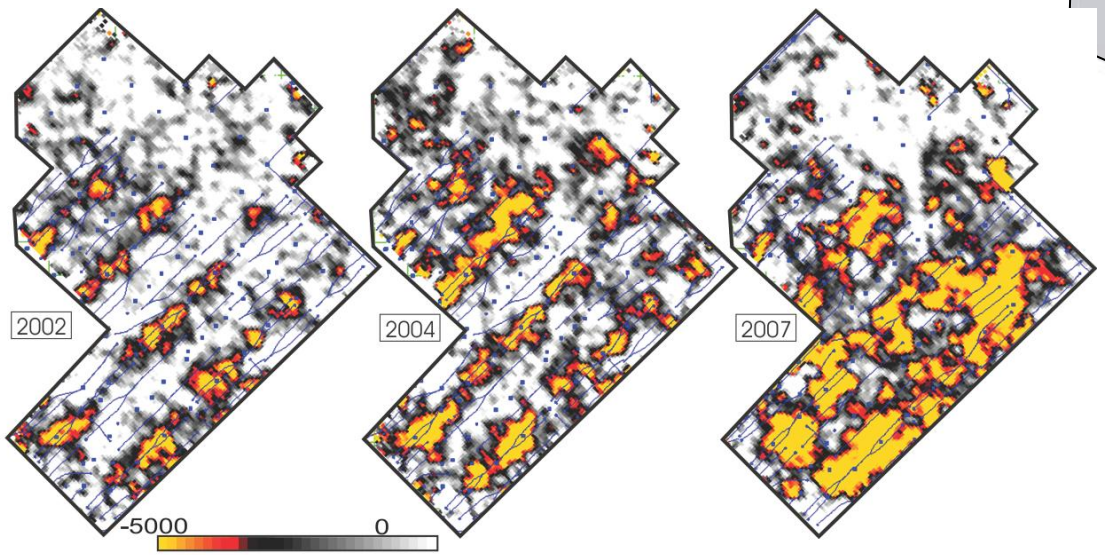
3D Time-Lapse Seismic: CO_2 Distribution

Monitoring regional subsurface distribution of CO_2:

- *Verifying storage conformance*
- *A primary input for updating reservoir models*
- *Optimal resolving capability*
- *Sensitive to low CO_2 saturations*
- *Data repeatability is fundamental*





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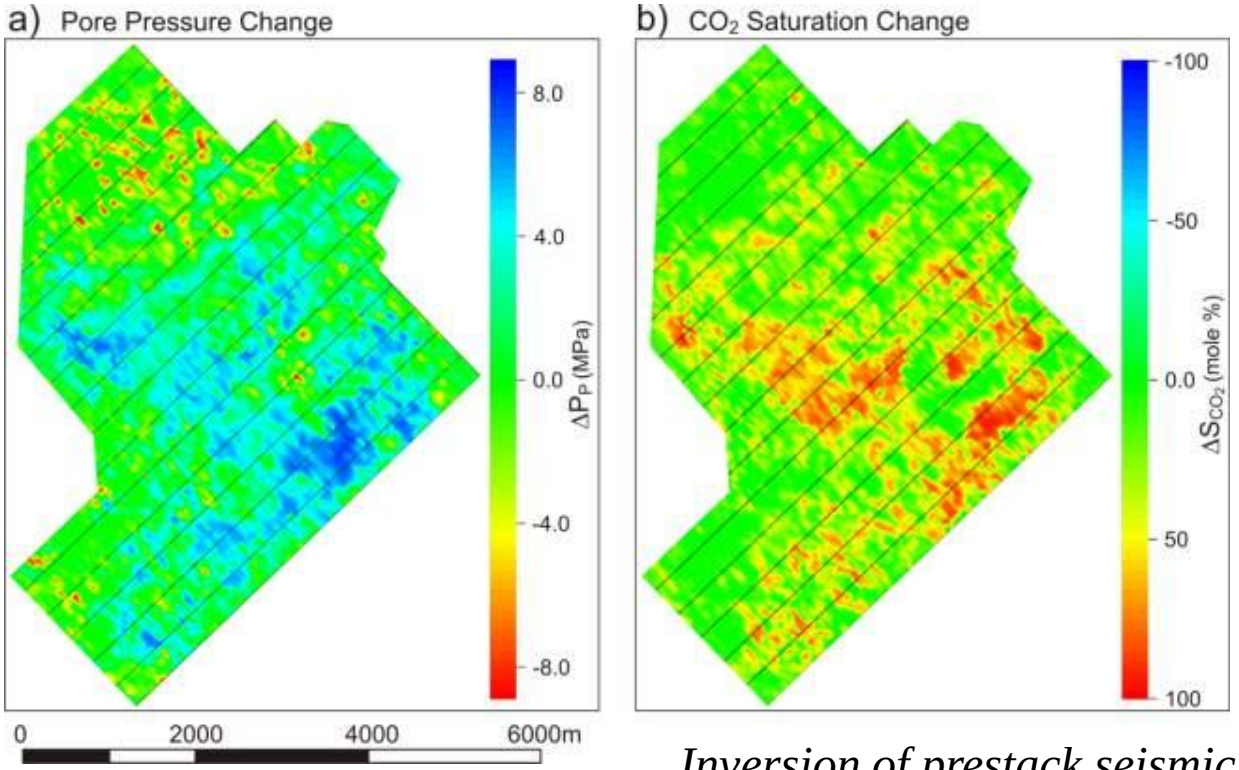
3D Time-Lapse Seismic: Pressure vs. CO_2 Saturation



Inversion of prestack seismic data:

- *Semi-quantitative CO_2 saturation and P changes*
- *Results are model-based*
- *Characterization of reservoir rock physics is essential*
- *Monitoring survey design is important as "long offset" data are required*

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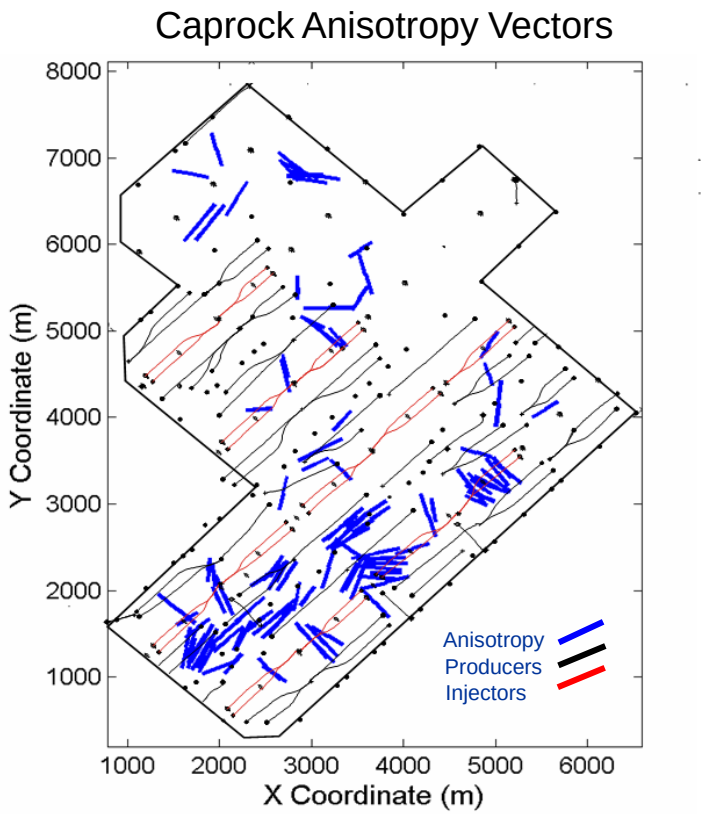
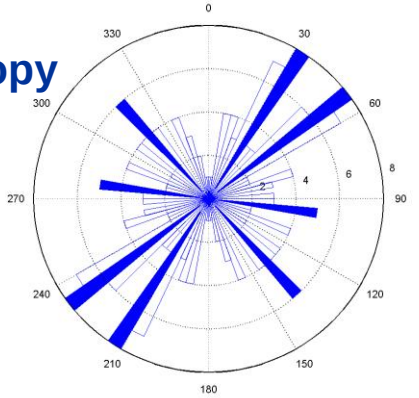
Seal Integrity: Fracture Mapping

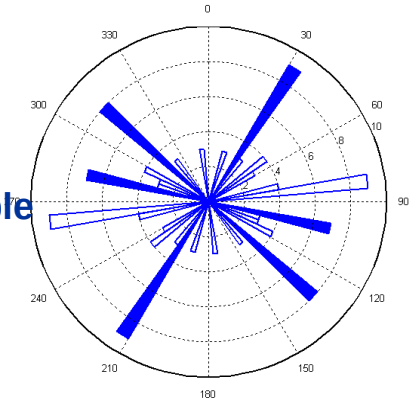


Anisotropy vectors



Bunge, 2000

Reservoir oriented core sample fracture analysis



Seismic anisotropy as a proxy for vertical fracturing:

- *Means of identifying potential fracture zones regionally*
- *Scale of individual fractures and hydraulic conductivity is not resolved*
- *"Fracture zones" may warrant subsequent attention*

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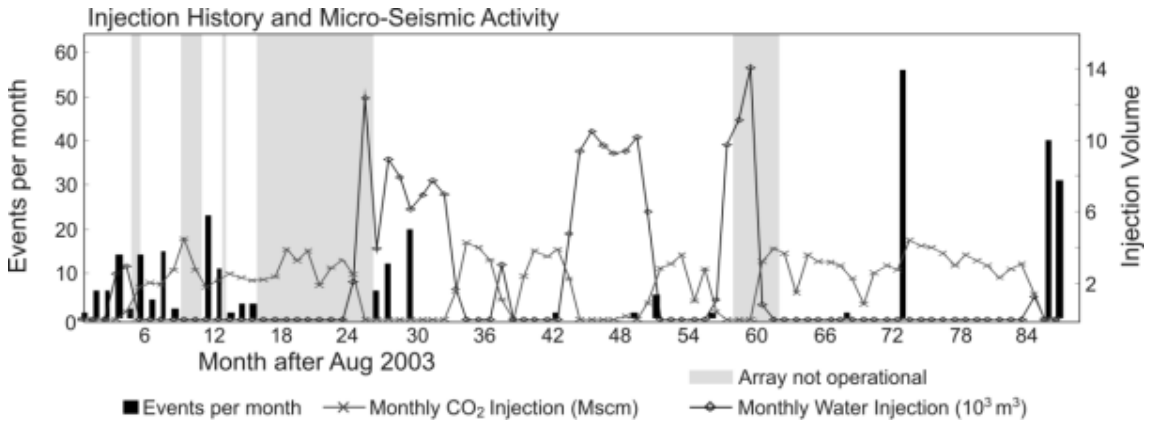
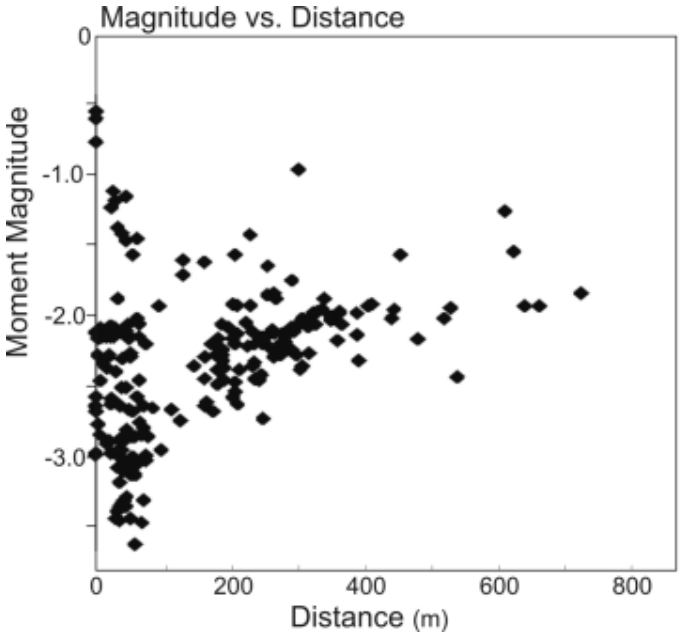
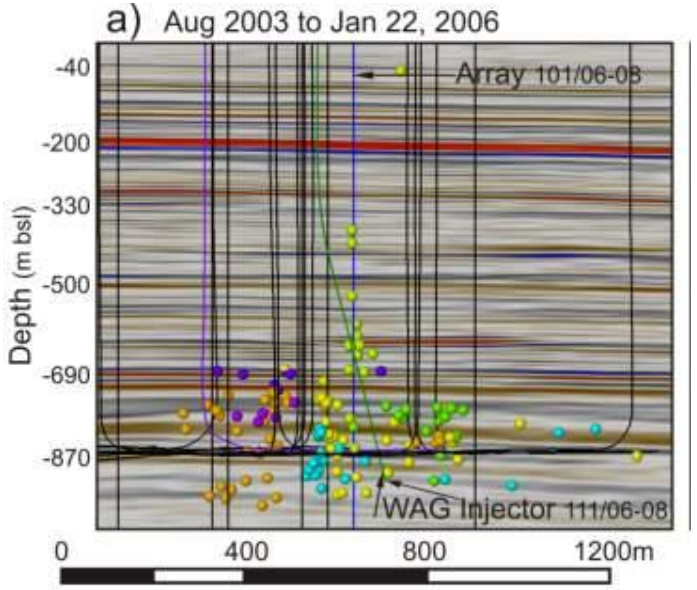
Passive Seismic Monitoring

Documentation of time, magnitude and location of seismicity:

- *Public assurance*
- *Integrity of the sealing units*
- *Injection control*







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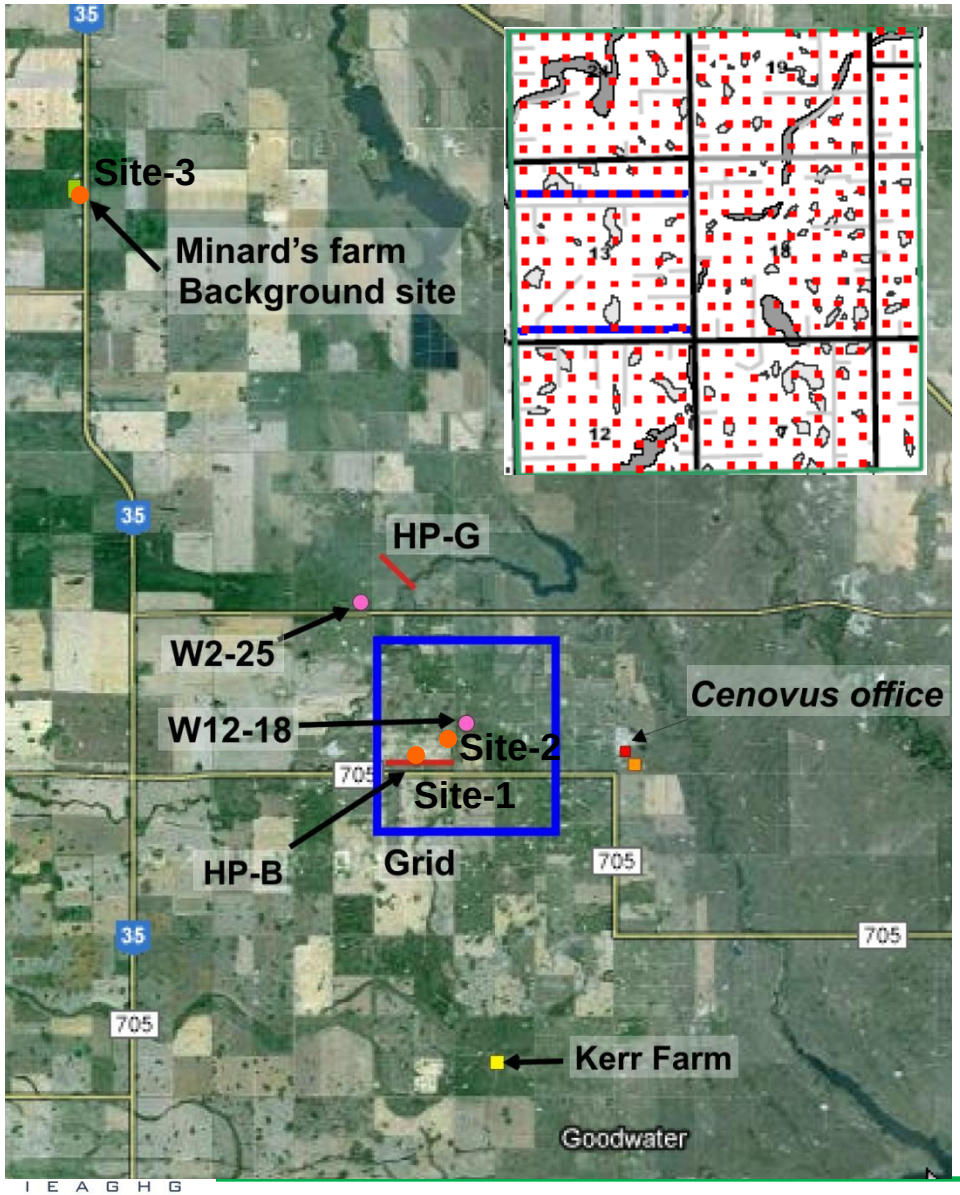
Soil gas monitoring: Overview



Research Providers

- ✓ Dave Jones et al. (BGS)
- ✓ Dave Risk et al. (StFX)

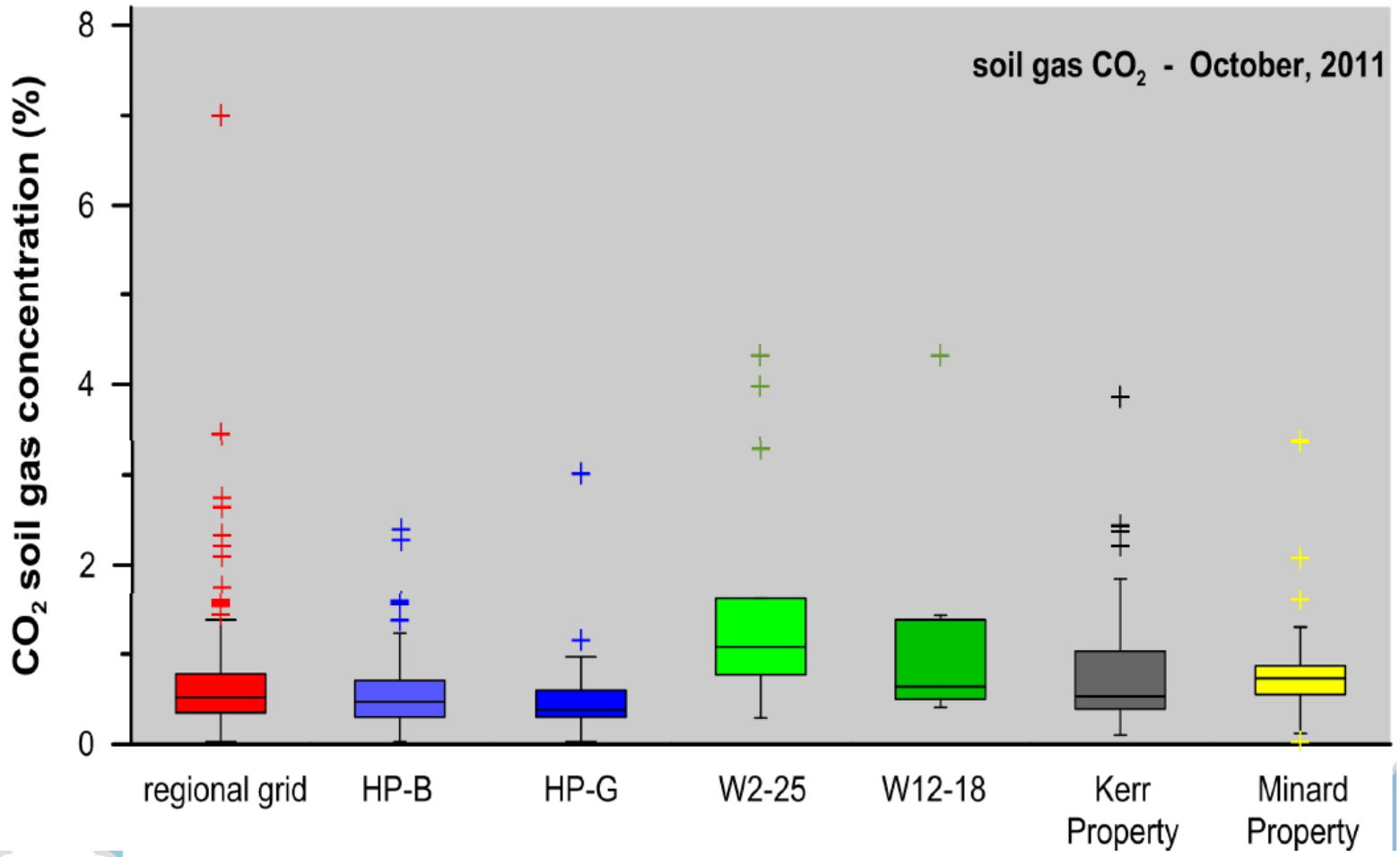
Measurements

- ✓ CO_2, O_2, N_2 conc.
- ✓ CH_4, C_2H_6, C_2H_4 conc.
- ✓ Rn, He conc.
- ✓ CO_2 flux
- ✓ C isotopes

Methods

- ✓ Single-depth (BGS), depth-profile (StFX) CO_2
- ✓ CO_2 flux (BGS)
- ✓ Continuous CO_2 (BGS), CO_2 flux (StFX)
- ✓ $\delta^{13}CO_2$, $^{14}CO_2$

Soil Gas Monitoring Data



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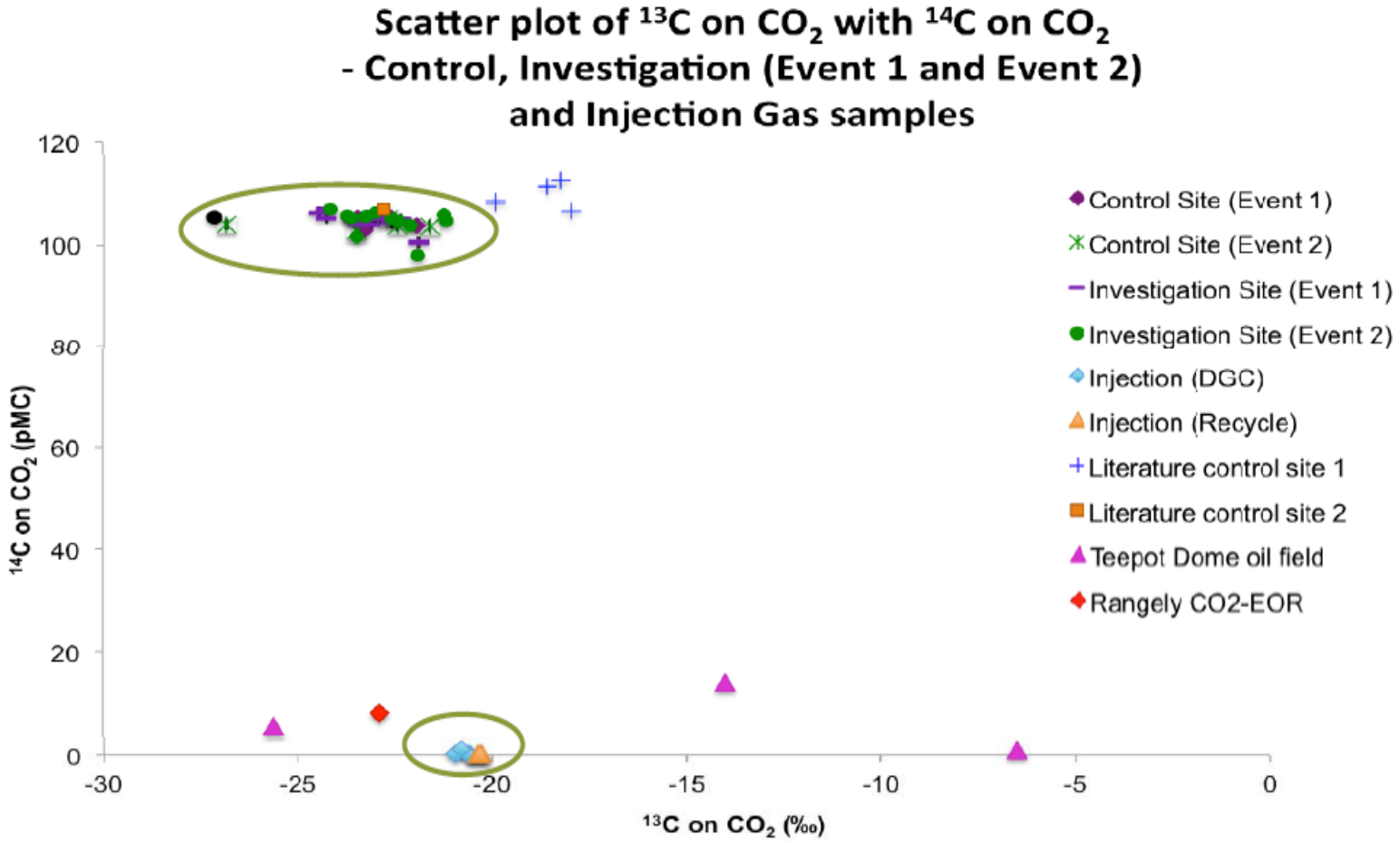
Carbon Isotopes



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Well Integrity: Field Testing Program

Modified coring tool:
→ Direct confirmation of cement

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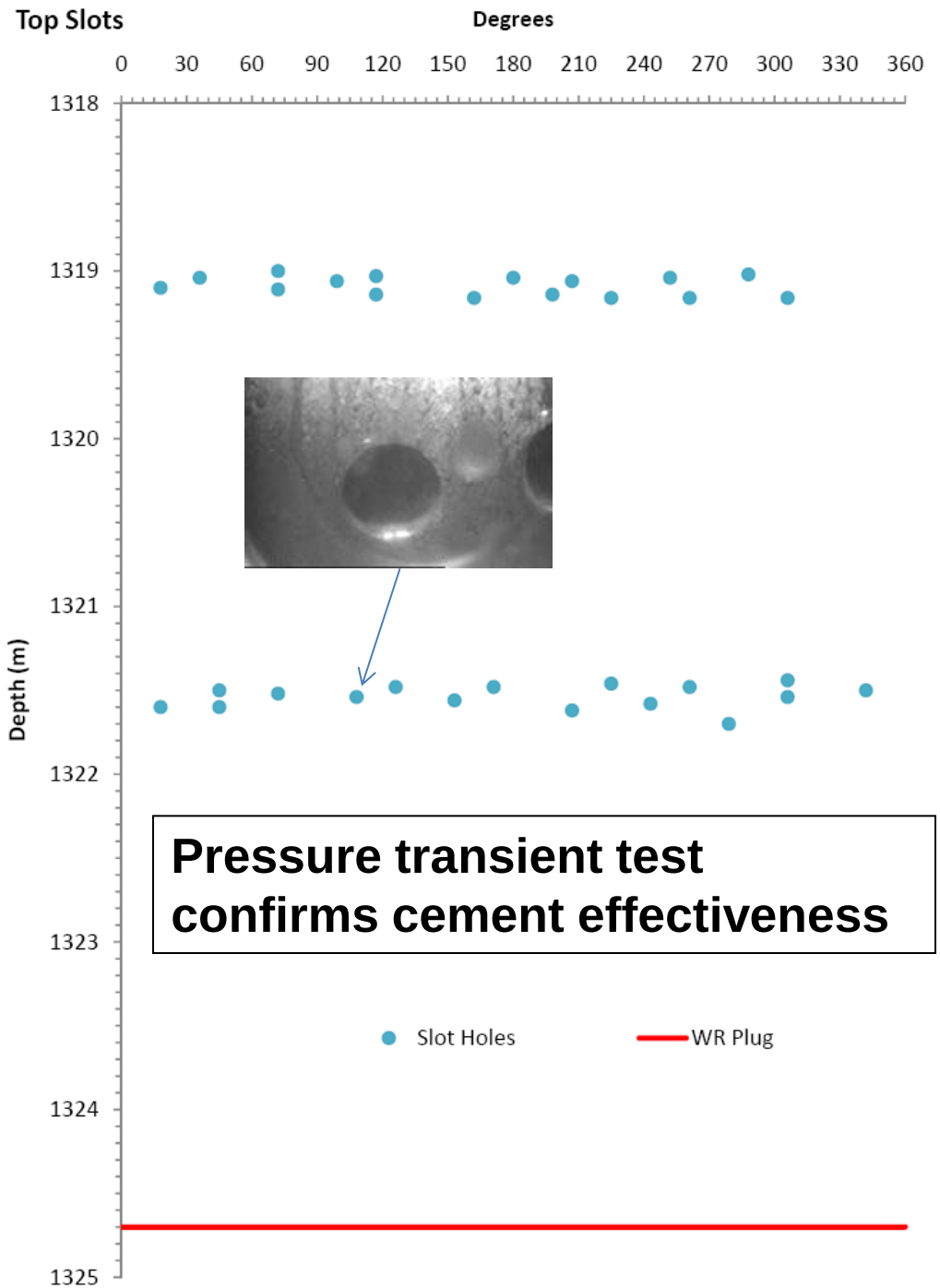

Field Testing Program

Process: Geosphere & Biosphere Risk

Technical Inputs
- Wellbore integrity research
- Characterisation of reservoir characteristics & transport of CO_2
- Seismicity of area
- Characterisation of CO_2 reactions in reservoir
- Monitoring techniques & effectiveness

Geosphere Risk Assessment

Outputs
- CO_2 risk events (initiating event & pathway) & ranking
- Mass of CO_2 released if event occurs
- Likelihood of each event occurring & releasing CO_2

Stakeholder Engagement

Stakeholder Values

Building Capacity to Engage

Biosphere Risk Assessment

Other Technical Inputs
- Characterisation of aquifers
- Characterisation of surface water
- Characterisation of soils / sediments
- Behaviour of CO_2 in soils, sediments, groundwater, surface water
- Receptors in environment
- Toxicology (animal, plant, human)

Outputs
- Risks to biosphere assets (ranking & severity)

Acceptability of Risks

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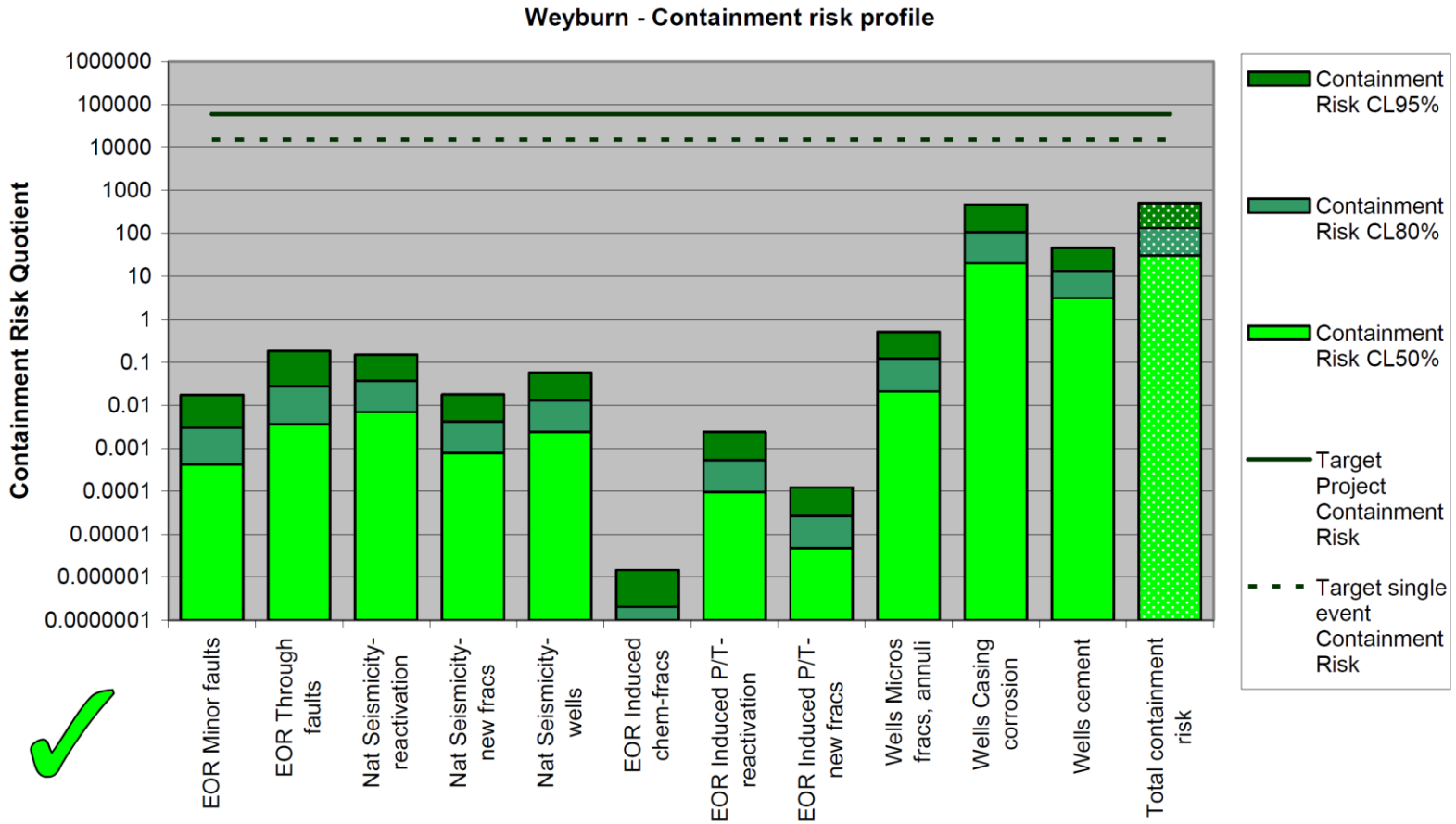
Mitigation Measures

Containment Risk Profile

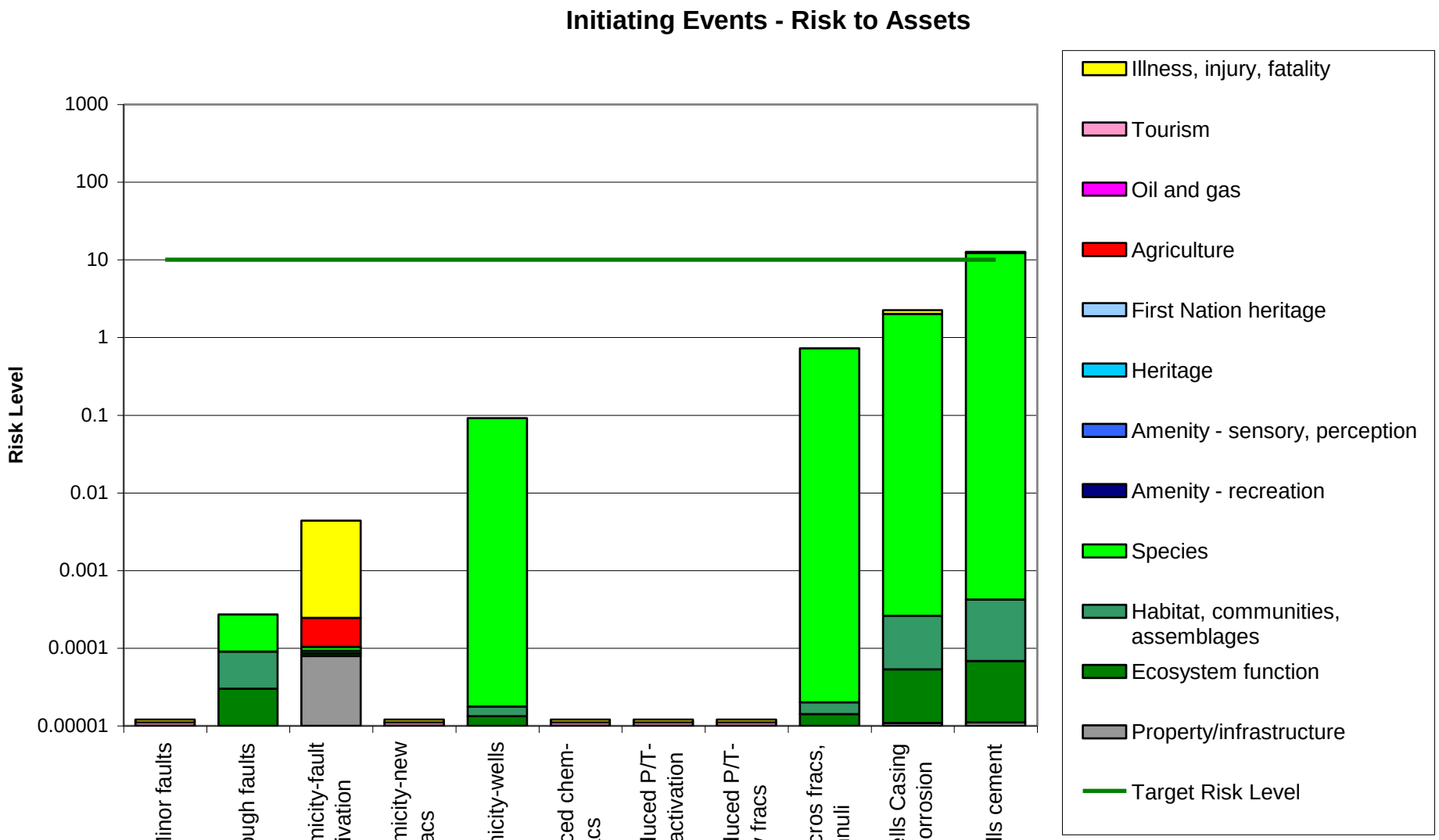
The storage will retain most of the CO_2 injected

Containment risk assessment



No further work would be required to demonstrate containment acceptability.

Identifying Biosphere Assets Most At Risk From Pathways



Thanks for your attention

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