



In Salah Gas

Geological Storage Assurance at In Salah

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**CSLF International Projects Workshop
Berlin, Germany 29th September 2005**



Agenda



- **In Salah Project(s) Overview**

- In Salah Gas Development (1bcf/d \$2,000 million)
- In Salah CO₂ Storage (1mmtpa \$ 100 million)
- In Salah CO₂ Assurance R&D (CSLF \$ 30 million)



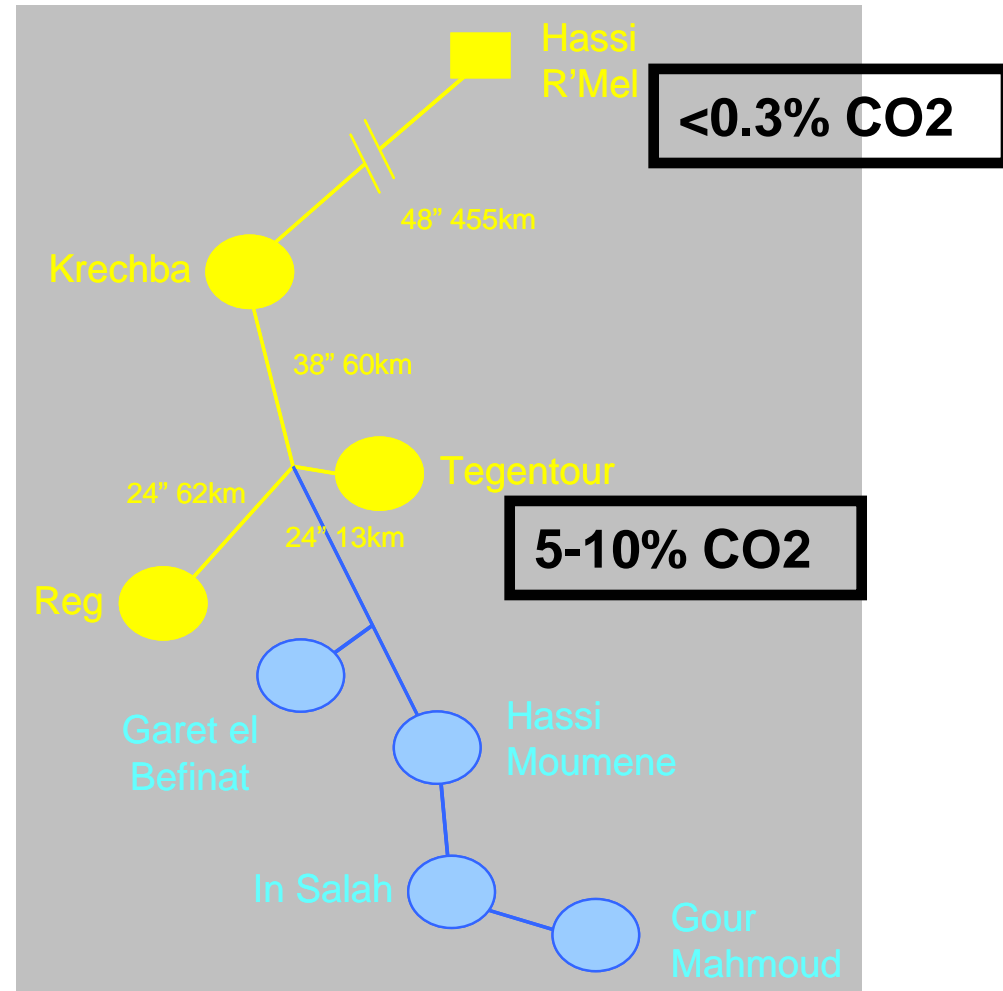
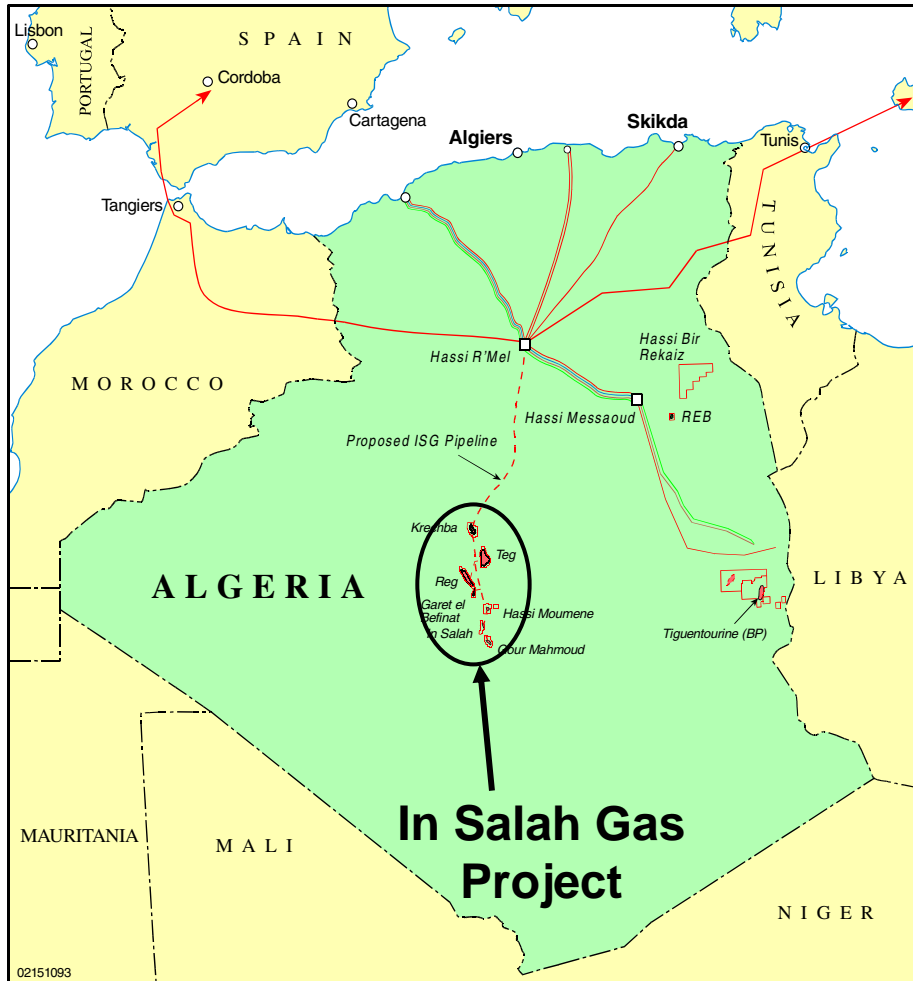
Agenda



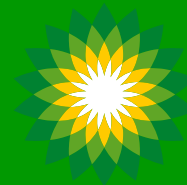
–In Salah Gas Development

- (1 bcf/d \$2,000 million)

The In Salah Gas Project



In Salah Gas Processing Plant



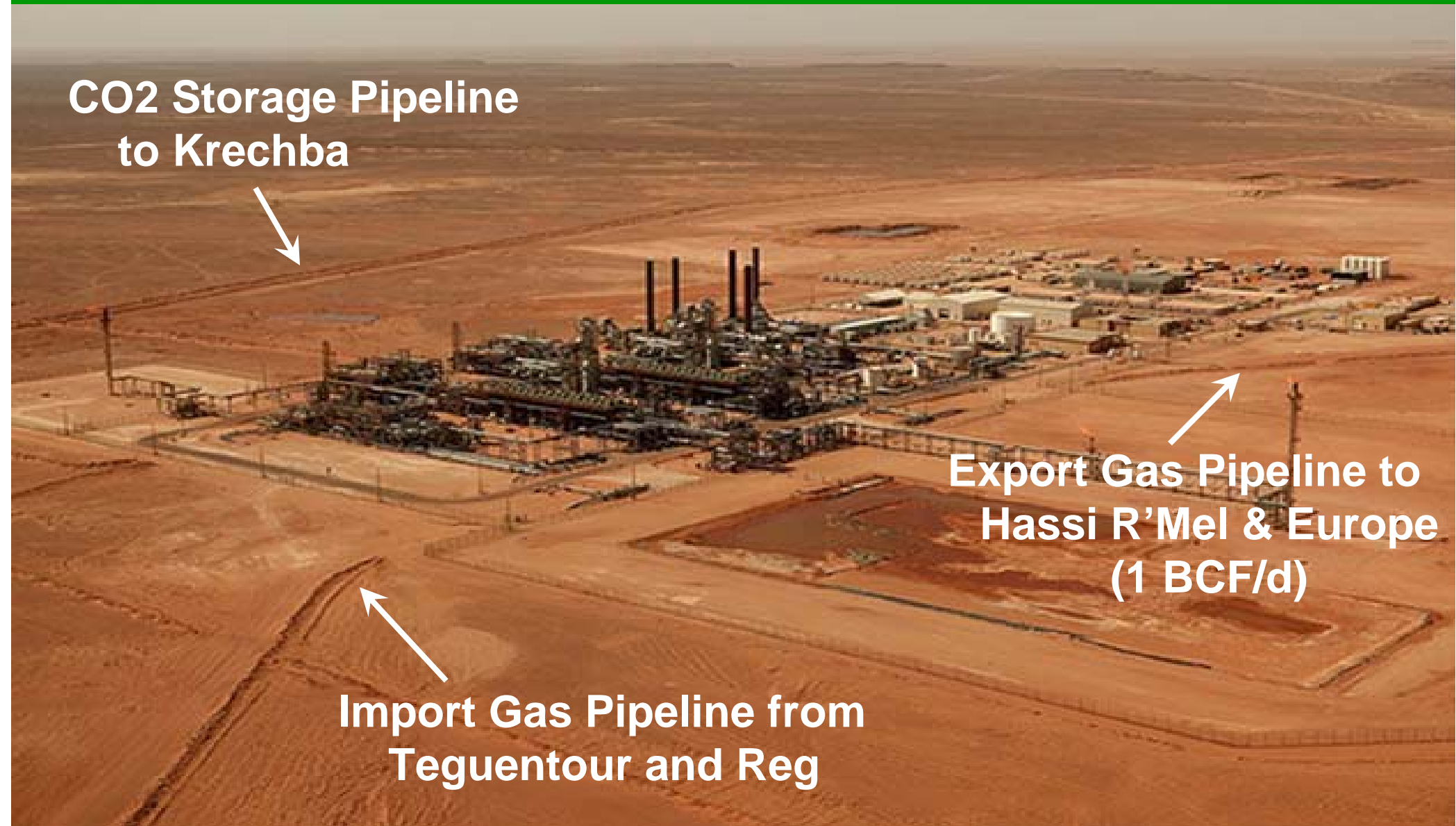
CO2 Storage Pipeline
to Krechba



Export Gas Pipeline to
Hassi R'Mel & Europe
(1 BCF/d)



Import Gas Pipeline from
Teguentour and Reg



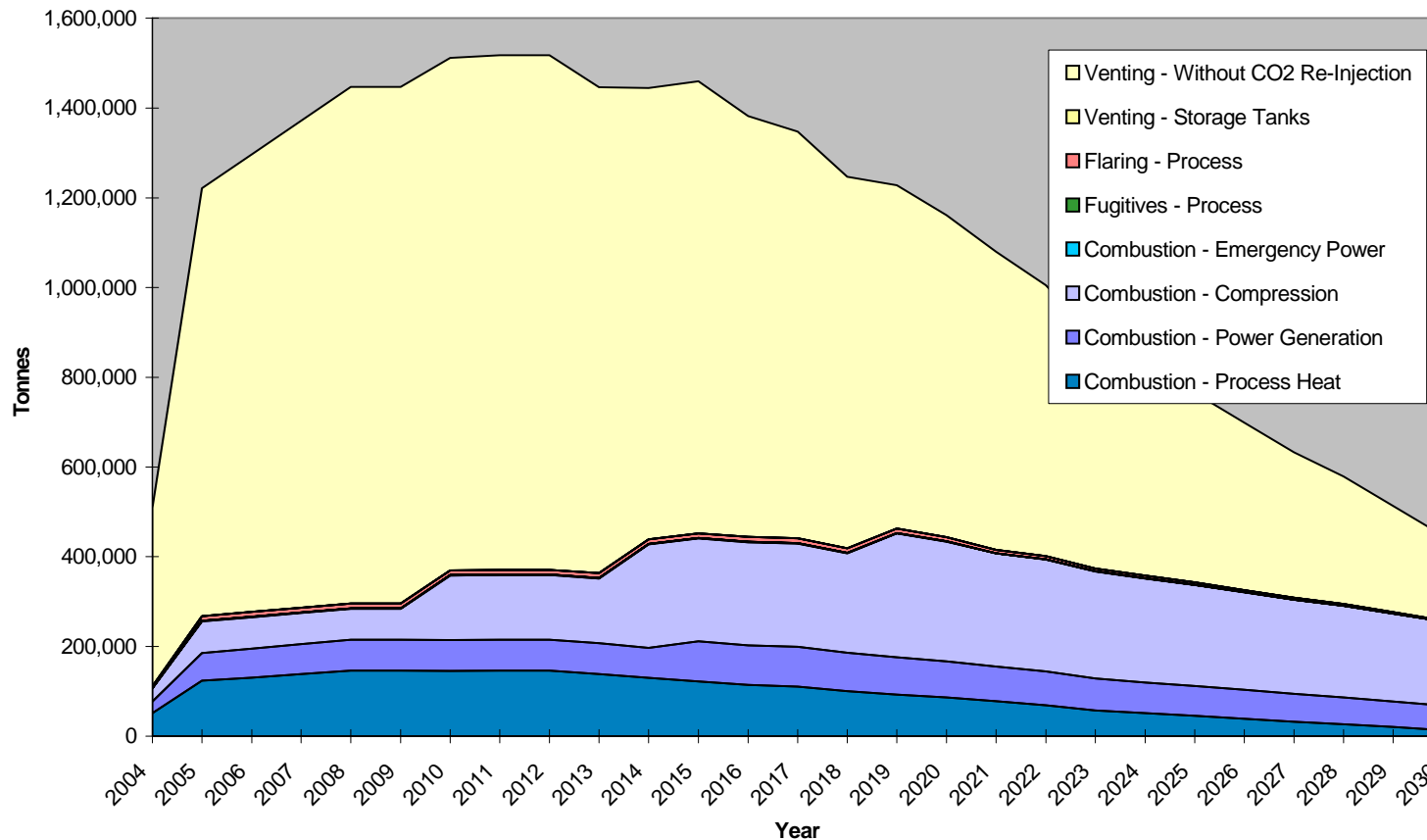
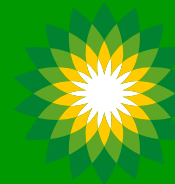
Agenda



–In Salah CO₂ Storage

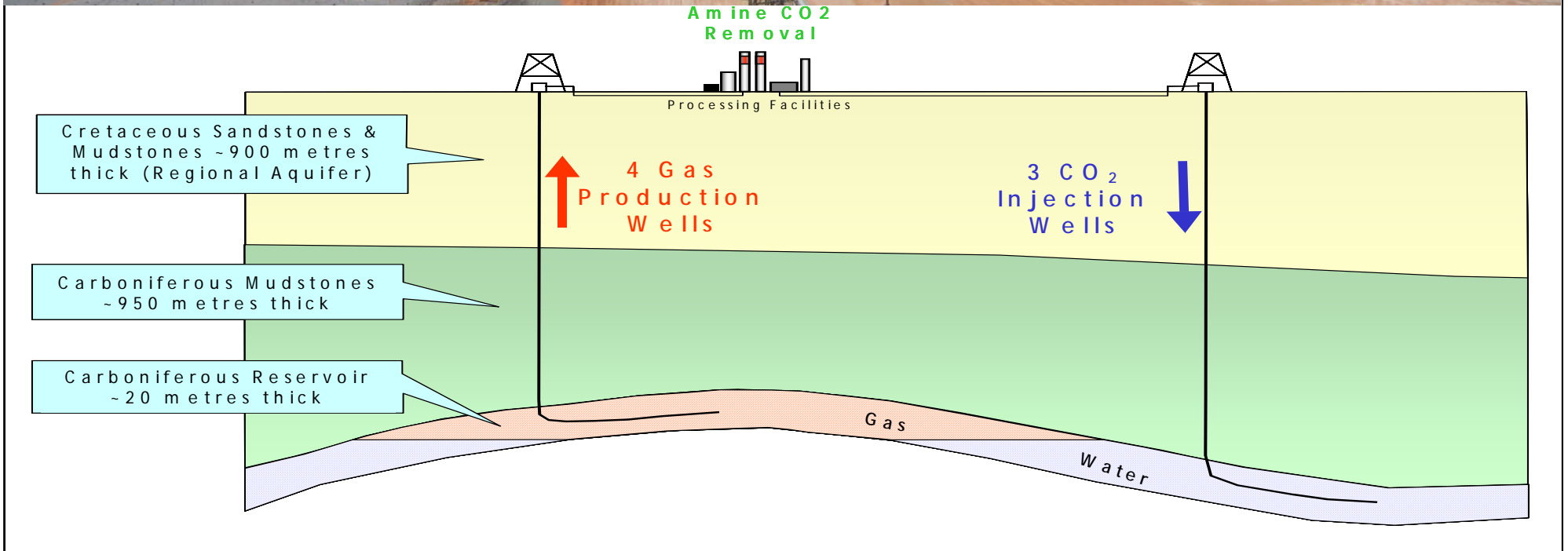
- 1 mtpa \$100 million

In Salah 25 Year CO₂ Profile



- Only the separated (yellow) CO₂ will be stored – the combustion CO₂ (blue) will be vented

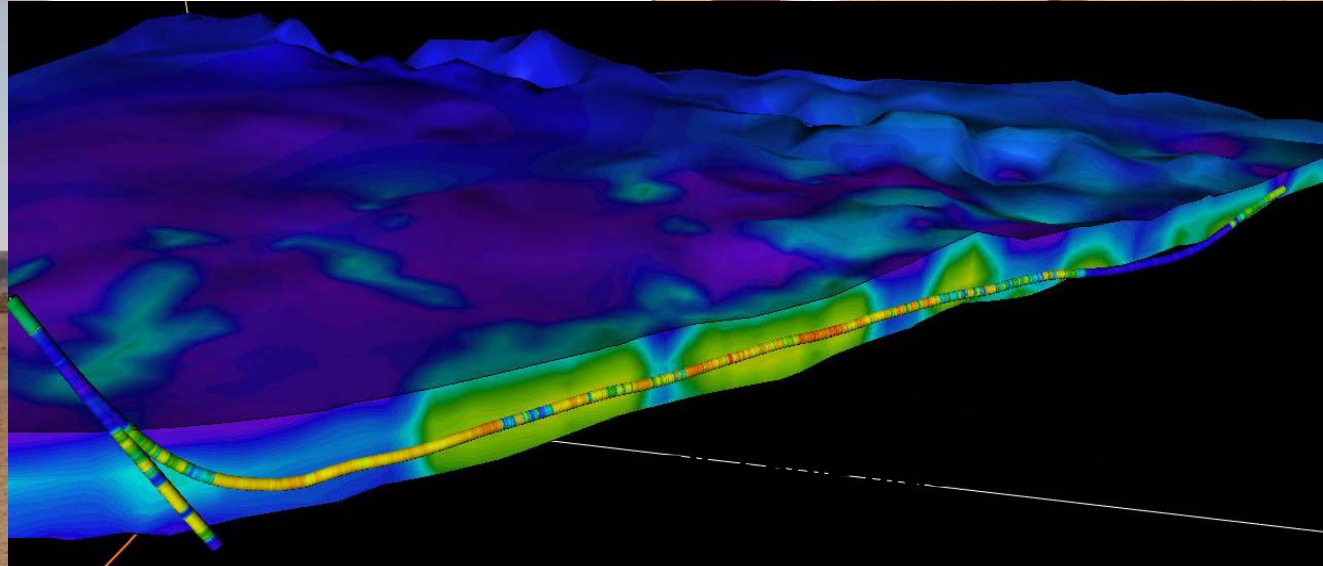
In Salah CO₂ Storage Operation



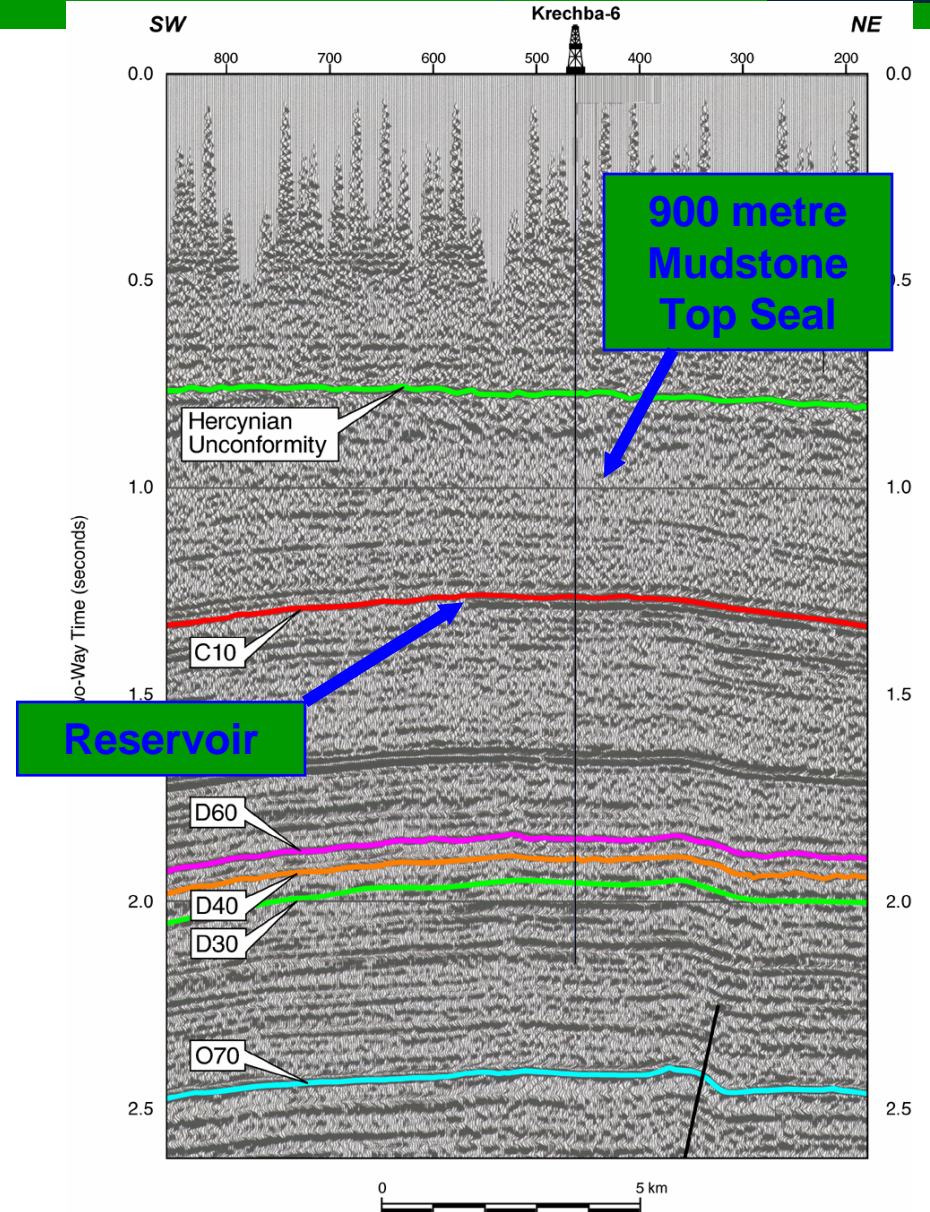
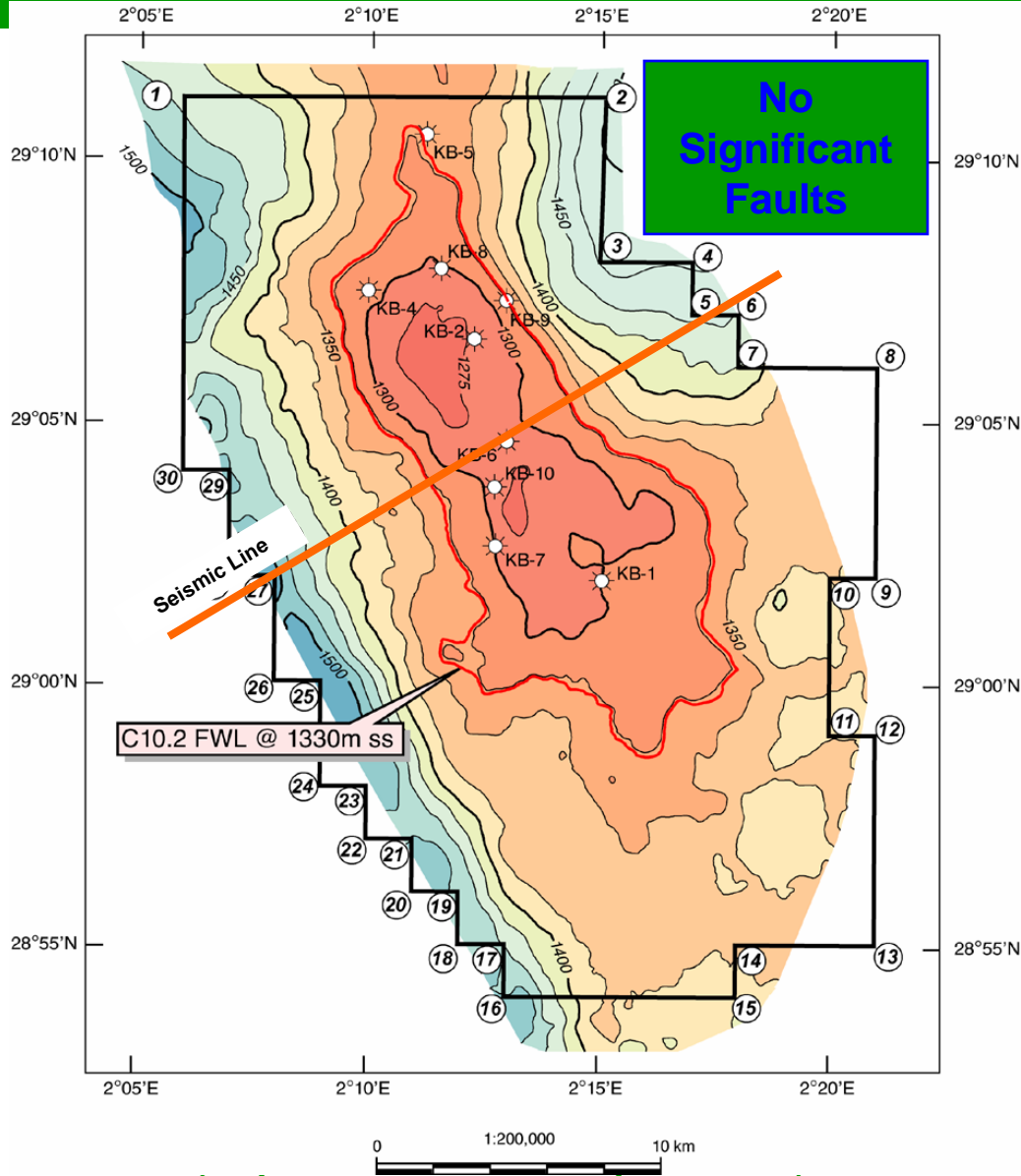
CO2 Storage Infrastructure



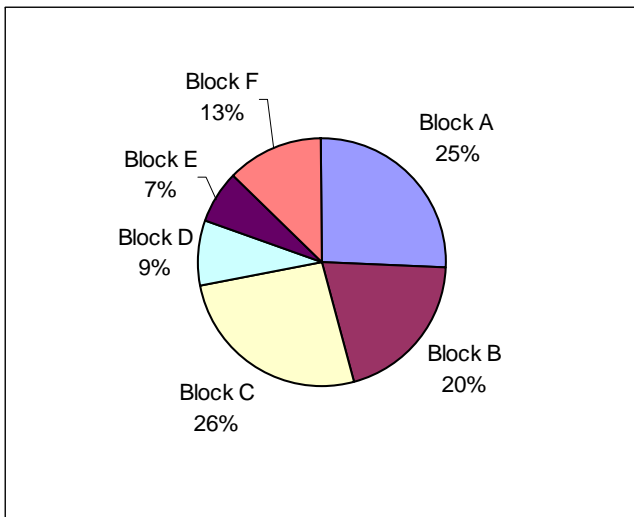
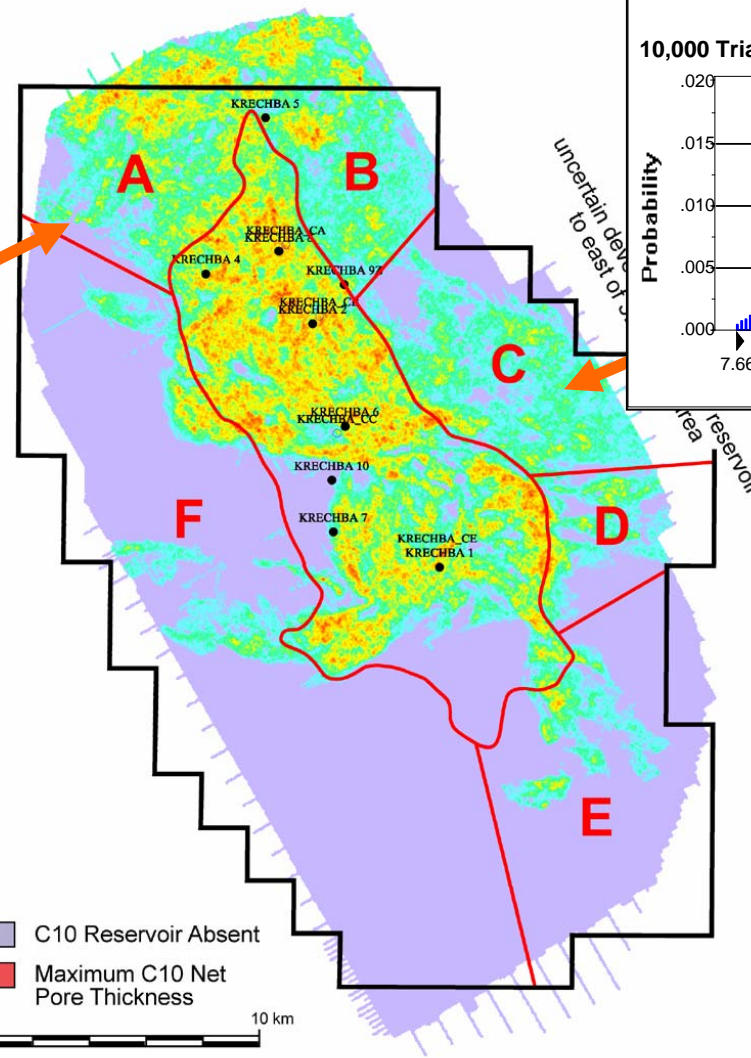
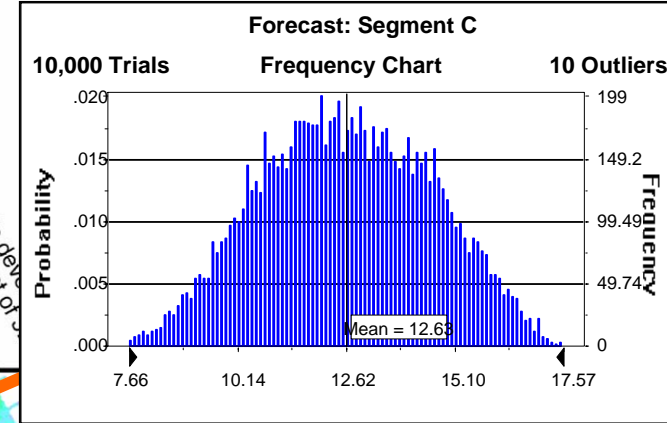
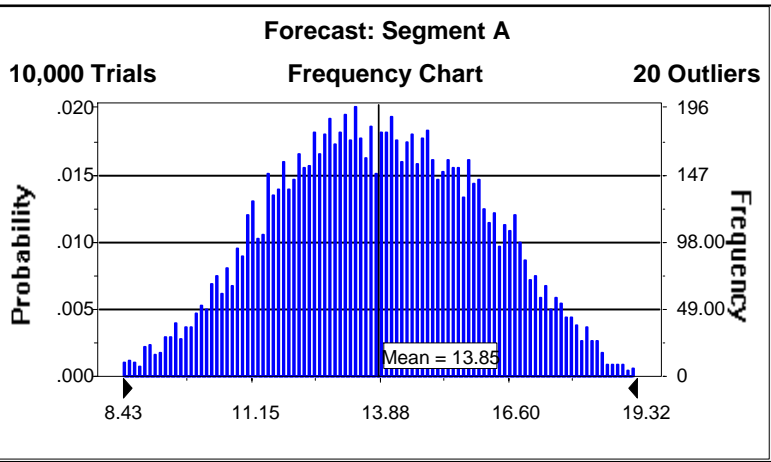
**50mmscf/d CO2
(1mmtpa)
Compression
Transportation
Injection
Storage**



Carboniferous Reservoir at Krechba



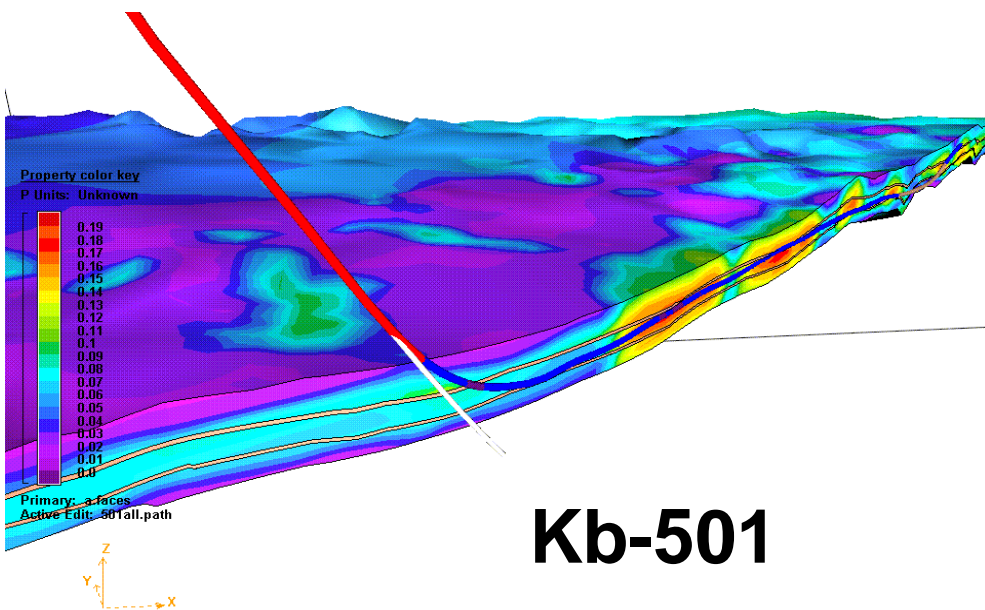
Forecast CO₂ Storage Capacity and Times (Years)



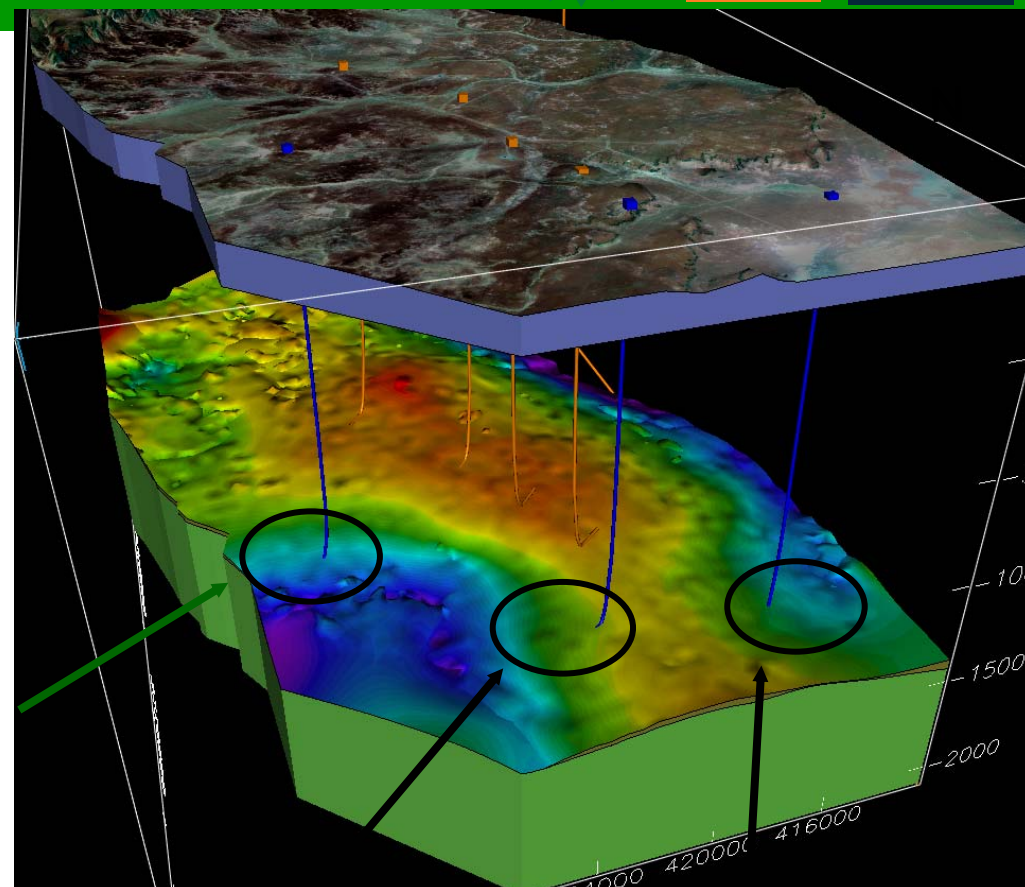
CO₂ Injection Wells



- Geosteering of wells to target high porosity / permeability intervals
- Well tests to assess injectivity



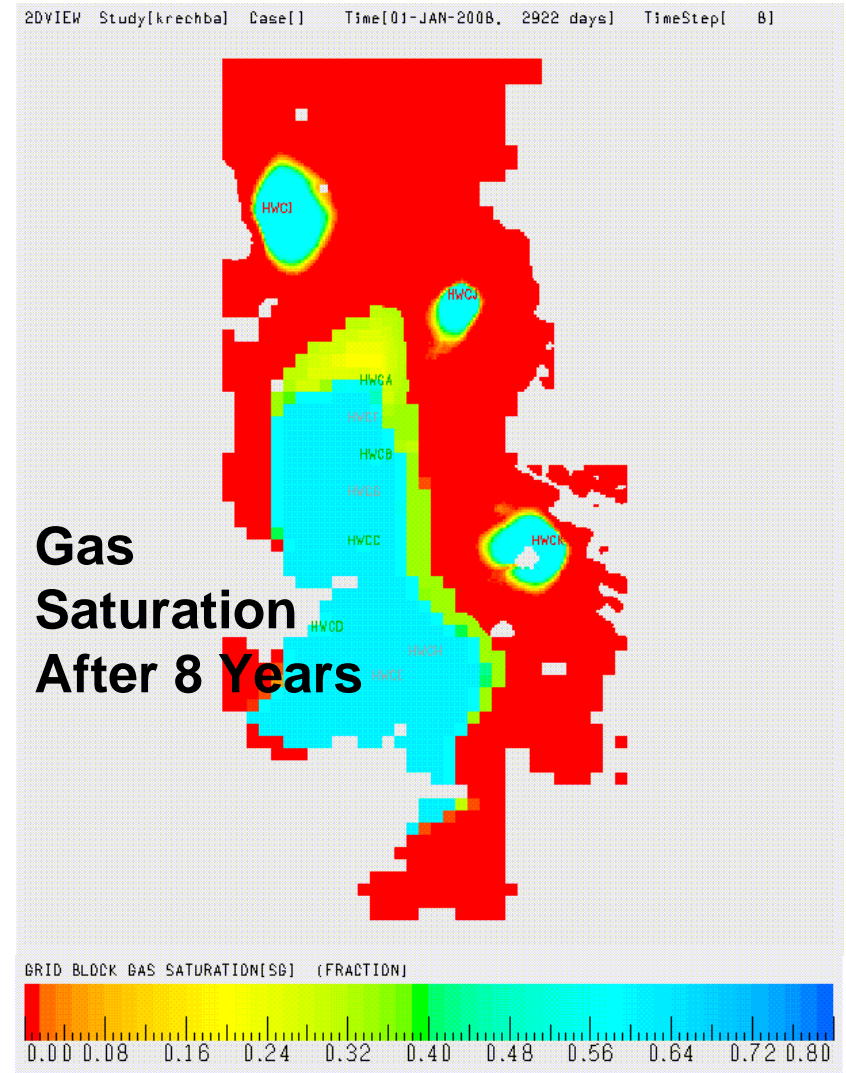
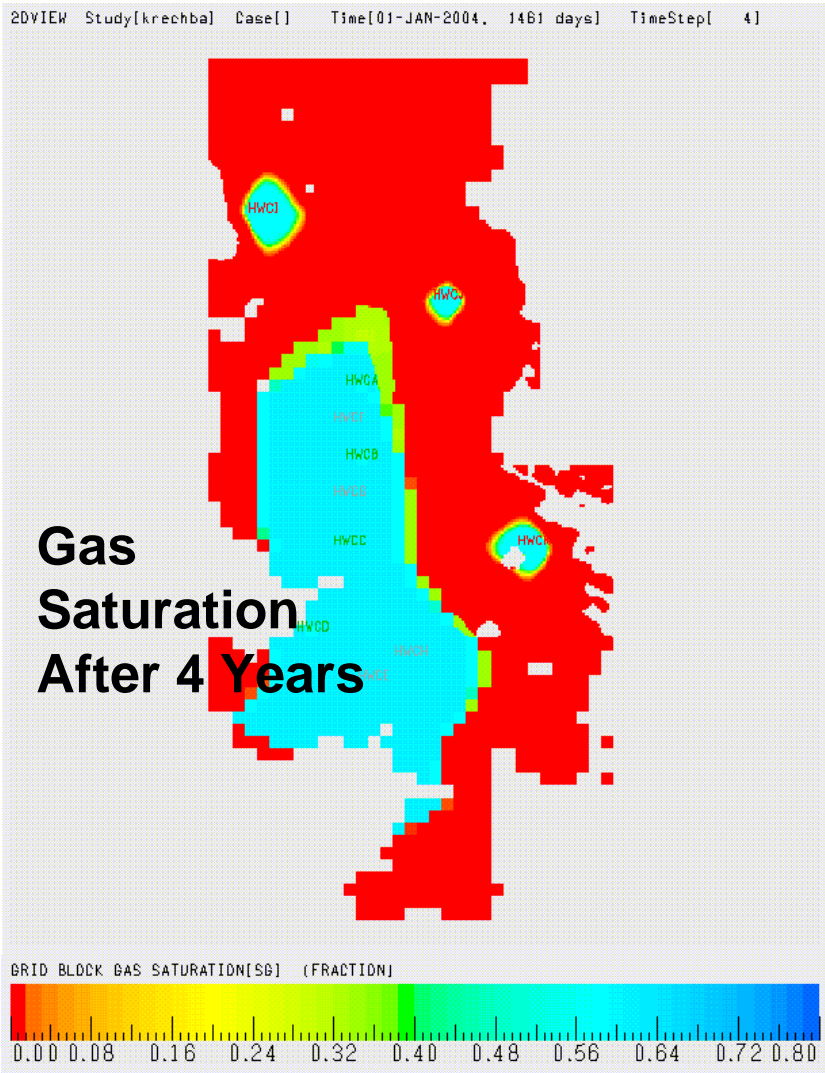
Kb-501



Kb-502

Kb-503

Simulated Impact of CO₂ Injection



Agenda



–In Salah CO₂ Assurance

- R&D (CSLF \$30 million)

Joint Industry R&D Project



Objectives (2004-09)

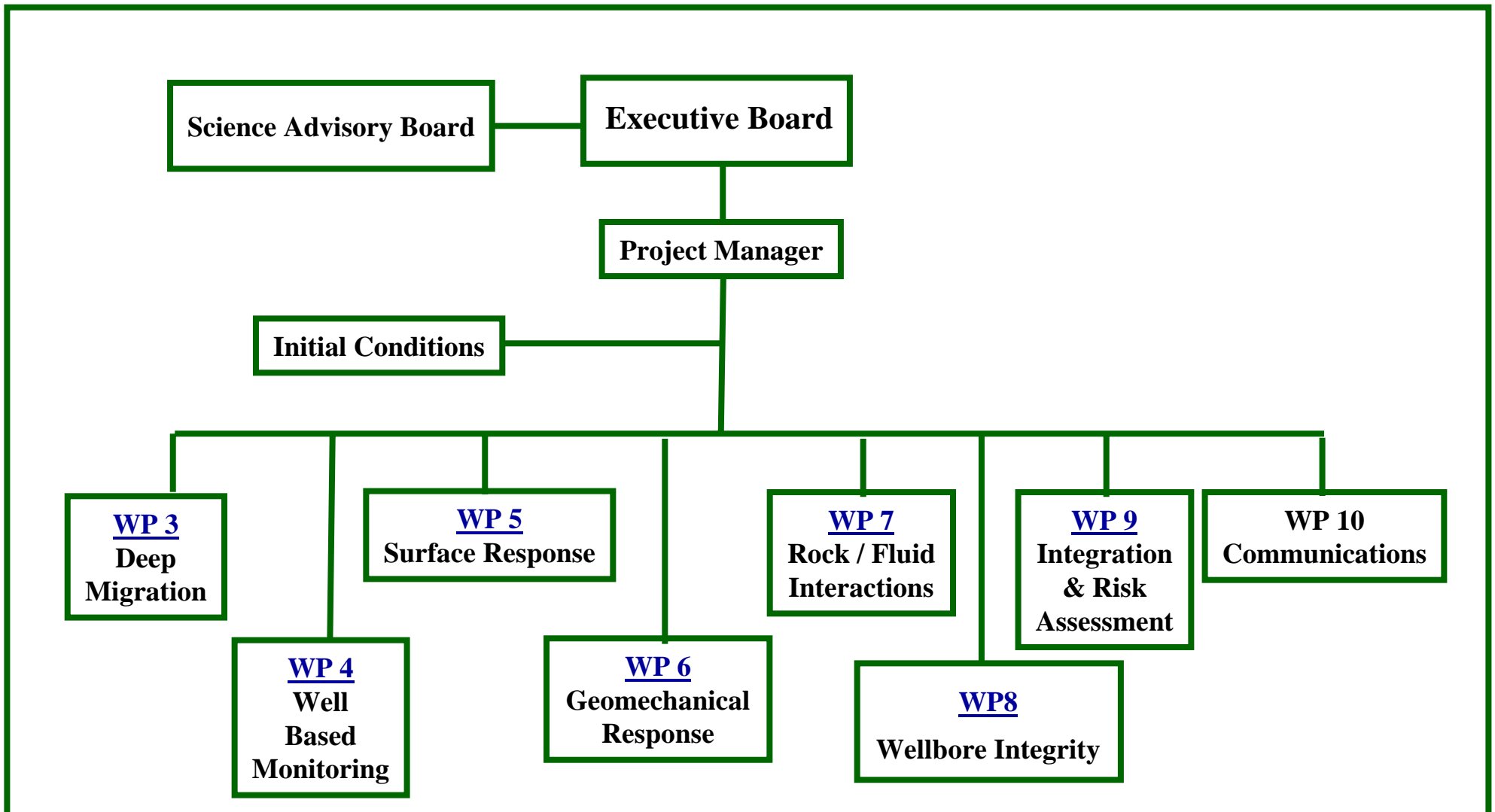
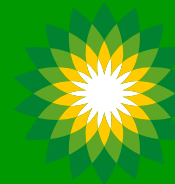
- 1. Provide assurance that secure geological storage of CO₂ can be cost-effectively verified and that long-term assurance can be provided by short-term monitoring.**
- 2. Demonstrate to stakeholders that industrial-scale geological storage of CO₂ is a viable GHG mitigation option.**
- 3. Set precedents for the regulation and verification of the geological storage of CO₂, allowing eligibility for GHG credits**

Technical Challenges

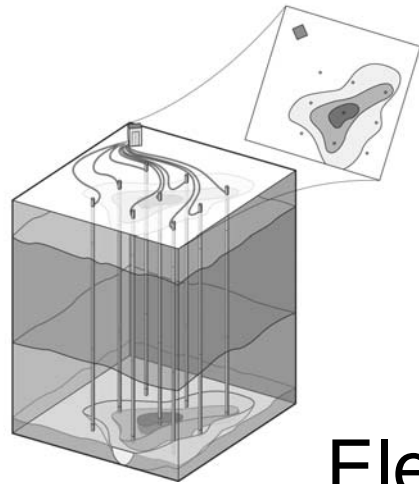
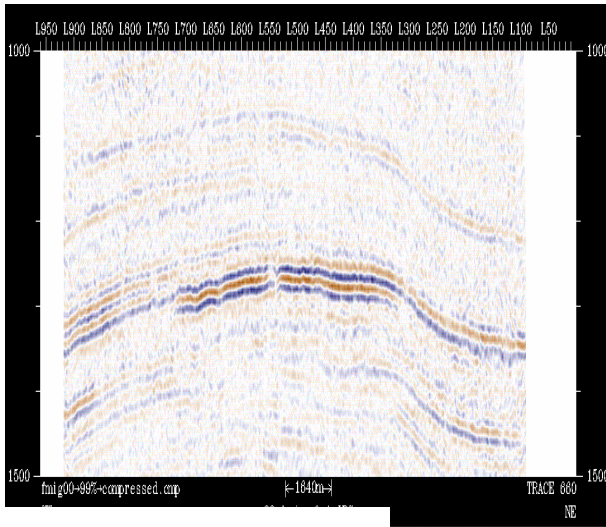


- **Storage duration**
- **Processes**
 - Migration
 - Geochemical
 - Geo-mechanical
 - Well-bore
- **Impacts and effects of leakage**
 - Where, how much, flux ?
- **Monitoring and mitigation**

Project Organization



Imaging Migration



Seismic

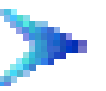
Gravity

Other :

Tracers

Tilt

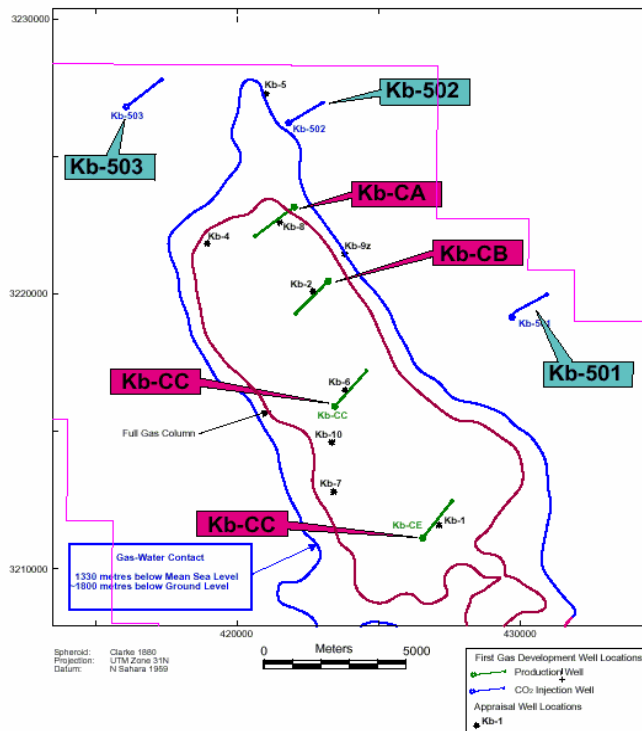
Streaming Potential



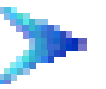
Well Based Monitoring



The Krechba Carboniferous Reservoir



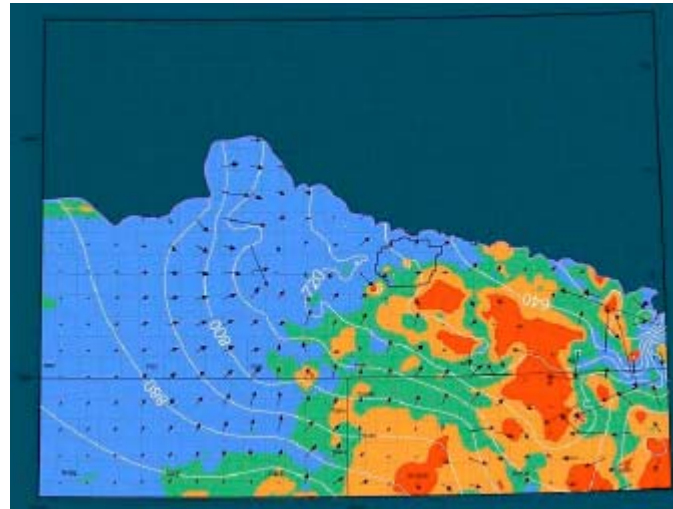
Observation Wells :
Deep well for gravity,
downhole micro-seismic, fluid
sampling, novel logging
Shallow observers to
monitor upper aquifers



Monitoring Geochemical Response



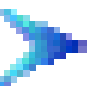
Aquifer hydrology



Aquifer chemistry
Gas chemistry
Produced water



Rock-fluid interactions

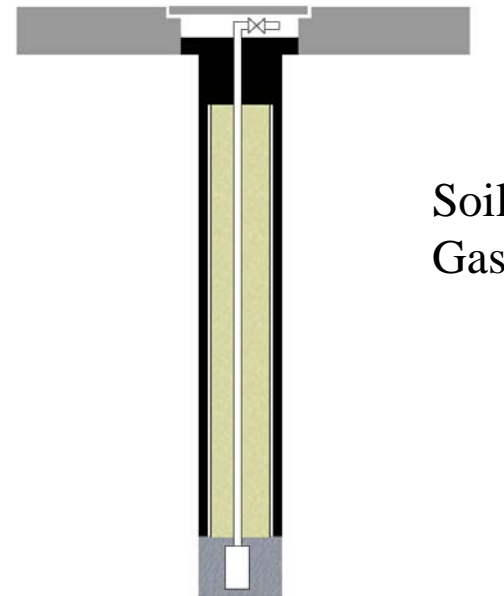


Monitoring Surface Response



Hyper-spectral Geobotanical
Monitoring may struggle !
Possible microbial action

Vadose zone dynamics :
P, T fluctuations

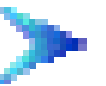


Meteorology :

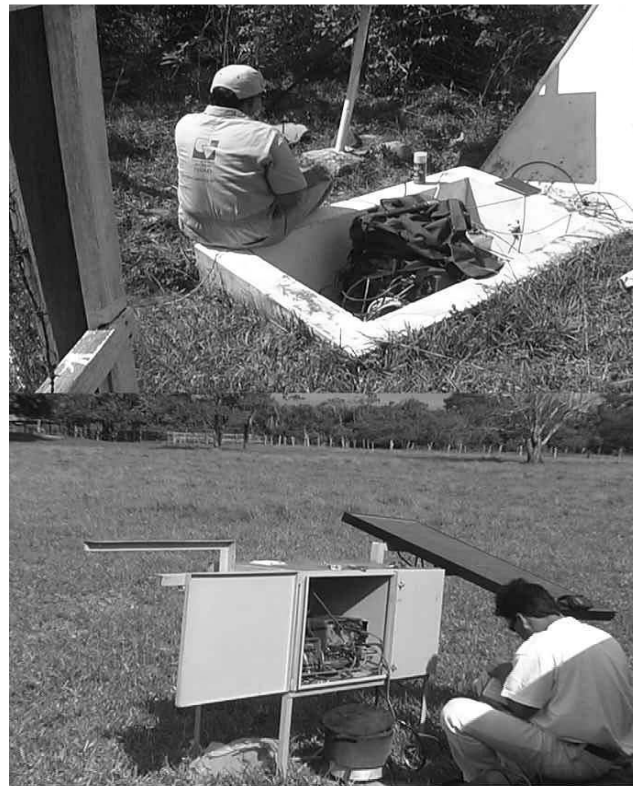
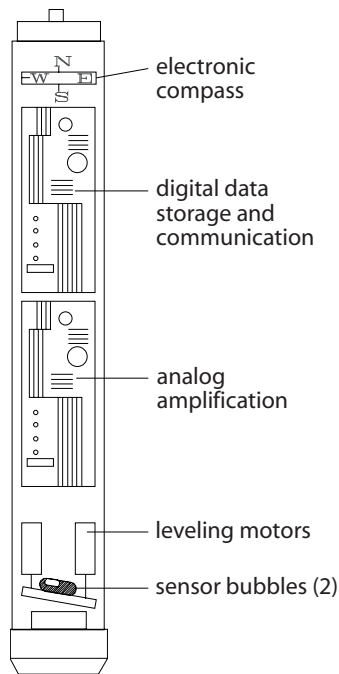
P,T, wind speed, direction

Eddy flux covariance

Laser scanning

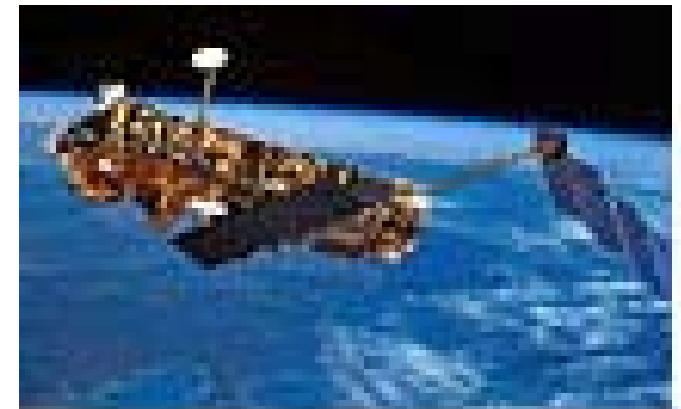


Monitoring Geomechanical Response



Tilt Meters

Microseismic



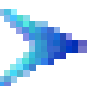
PSInSAR



Performance Modelling



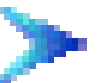
- Semi-regional scale to model regional fluxes and migration routes
- System model
 - Below reservoir to surface, 10 km outside CO₂ affected area
- Reservoir model
- Tools
 - Basin models e.g. Temis
 - Reservoir models e.g. VIP, GEM
 - Specialist geochemistry and geomechanical software
 - Vadose zone / atmospheric



Wellbore Integrity



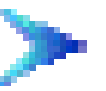
- Cement and materials integrity
 - Properties of new wells
 - Potential to sample old wells
- Simulation of durability
- Monitoring well integrity
 - Novel logging techniques
- Abandonment options
 - Plug materials e.g. high alumina cements
 - P&A methodology
 - Post-abandonment instrumentation



Seismic Strategy



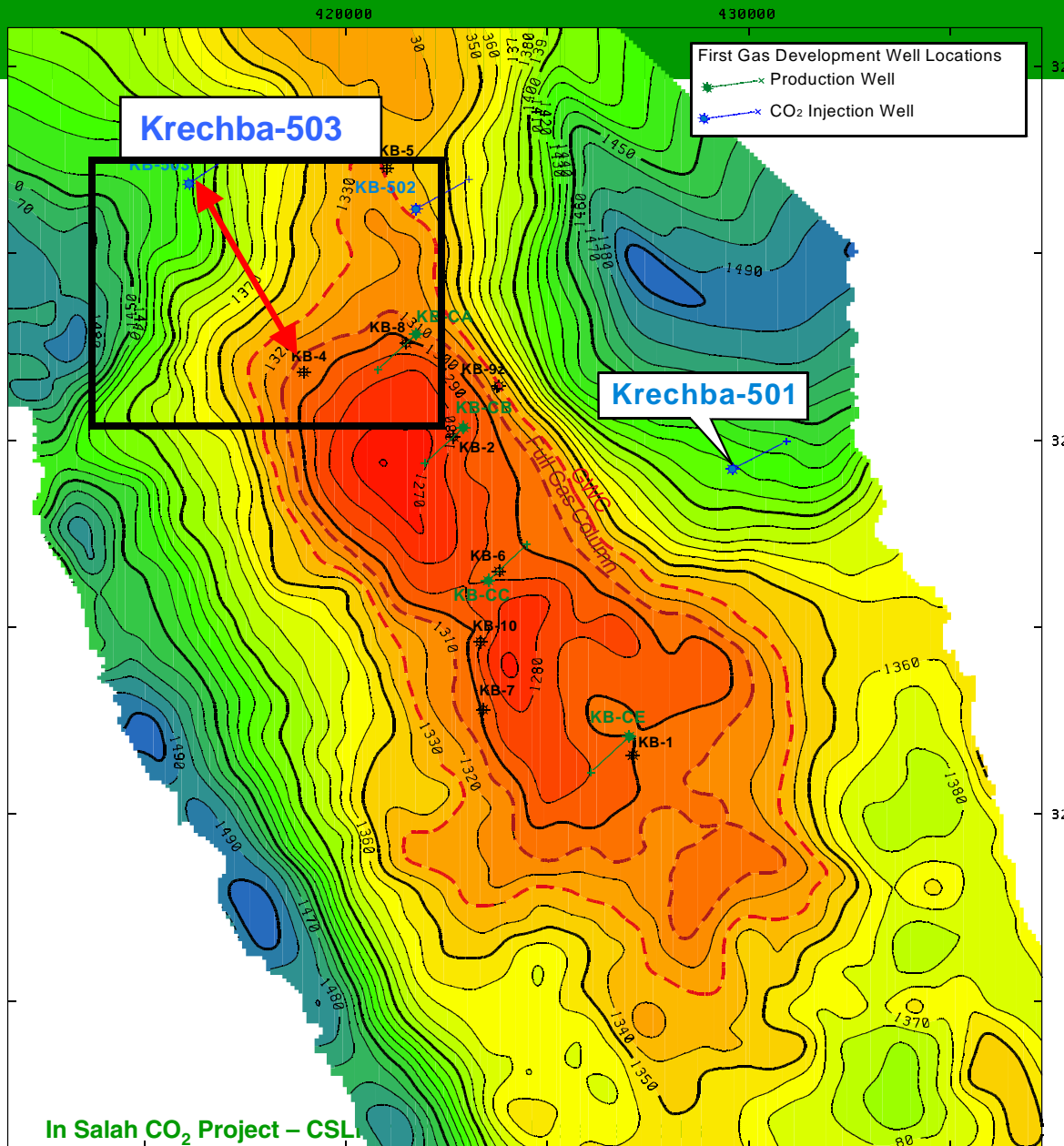
- **Existing Baseline 3D survey**
 - Data quality issues
- **4D data acquisition**
 - Small signal based upon forward modelling
 - High signal to noise
- **Options**
 - ‘Conventional’ repeats : two repeats at \$5 million each
 - Flat cable permanent array : \$7.5 million installation plus \$0.75 / repeat
 - Fibre optic detection and cabling : still under development



Focus on Permanent Seismic



Top Structure Map



Top Krechba C10_2 Depth Structure map

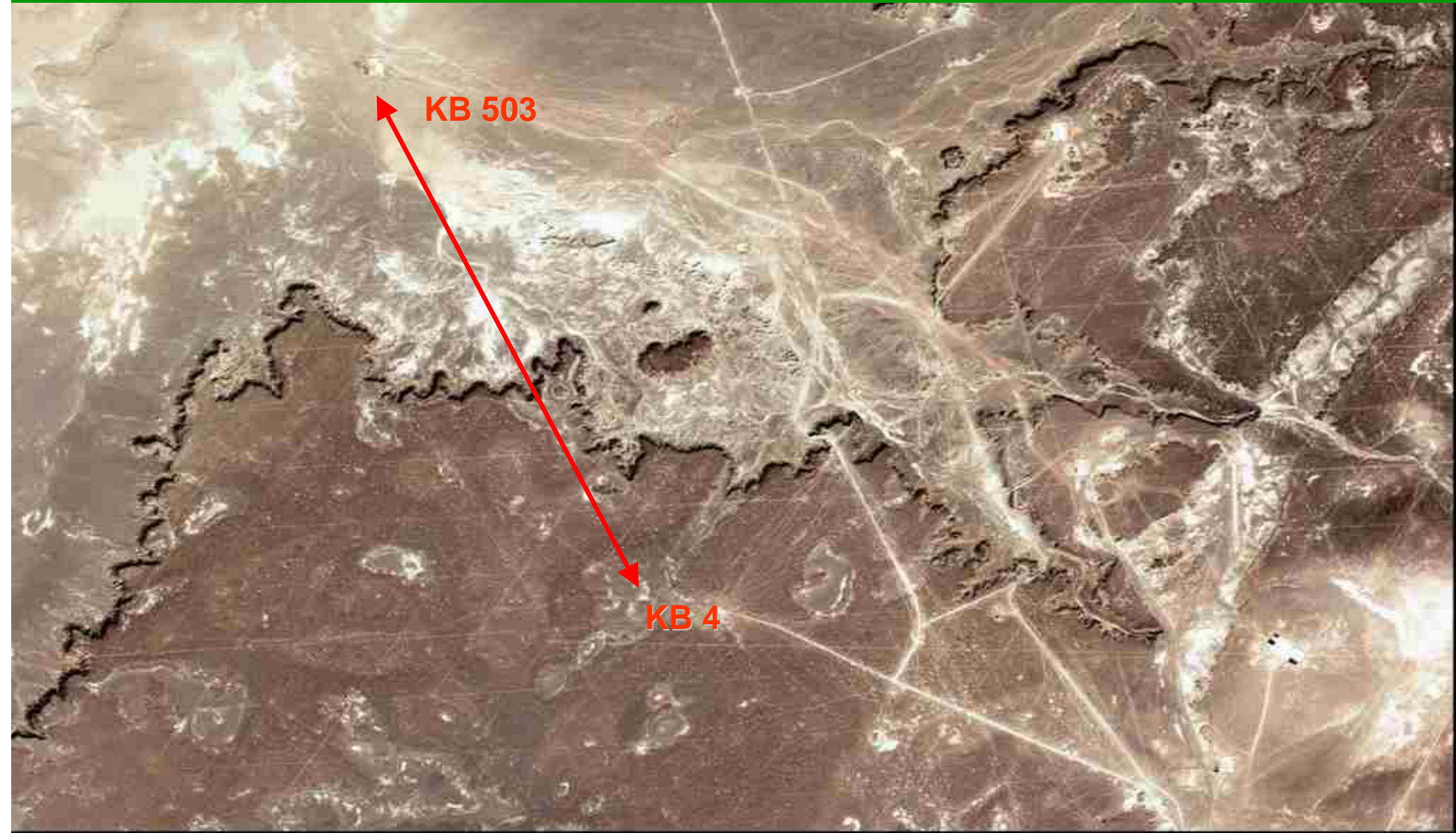
Surface Features



KB 503



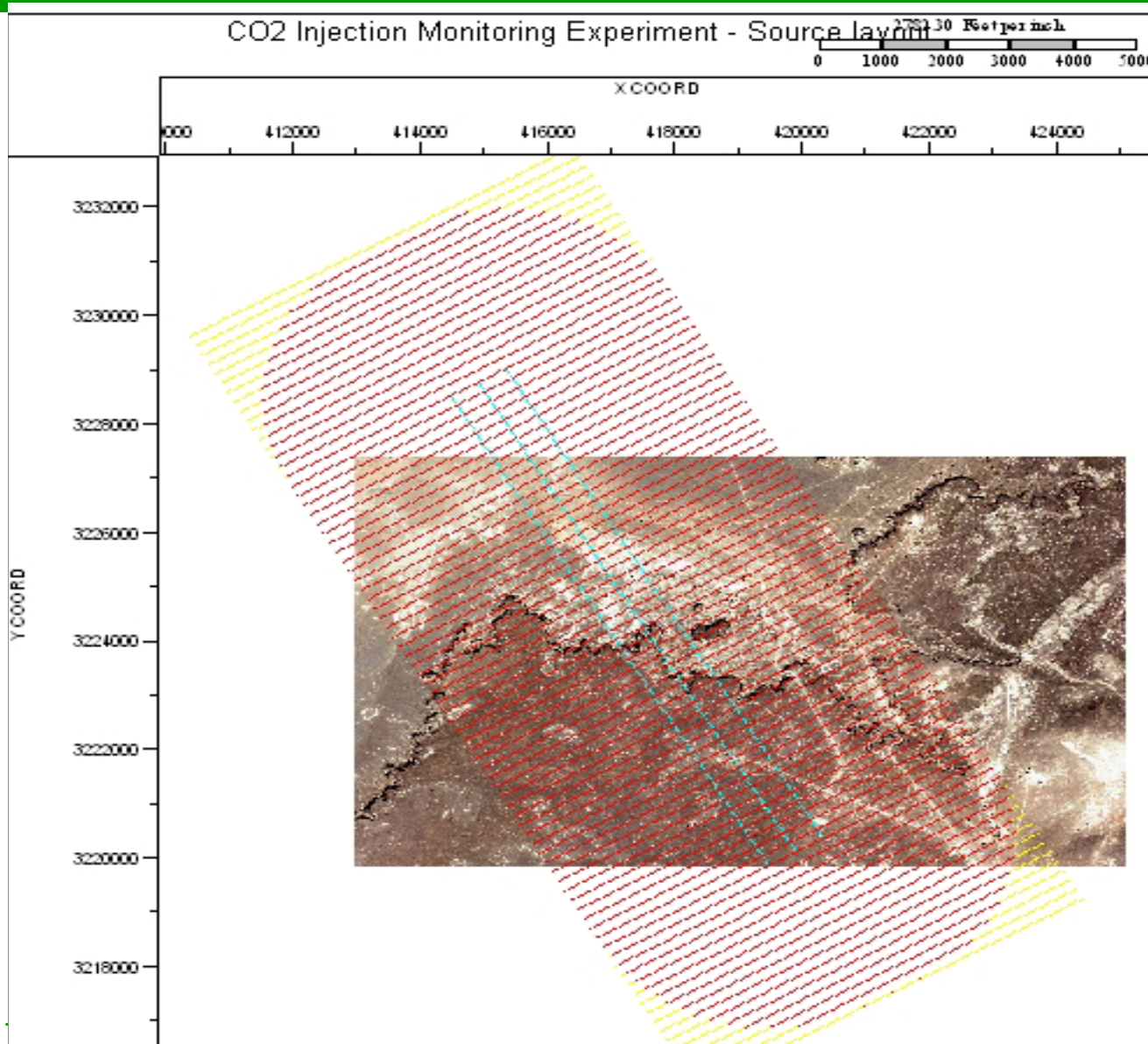
KB 4



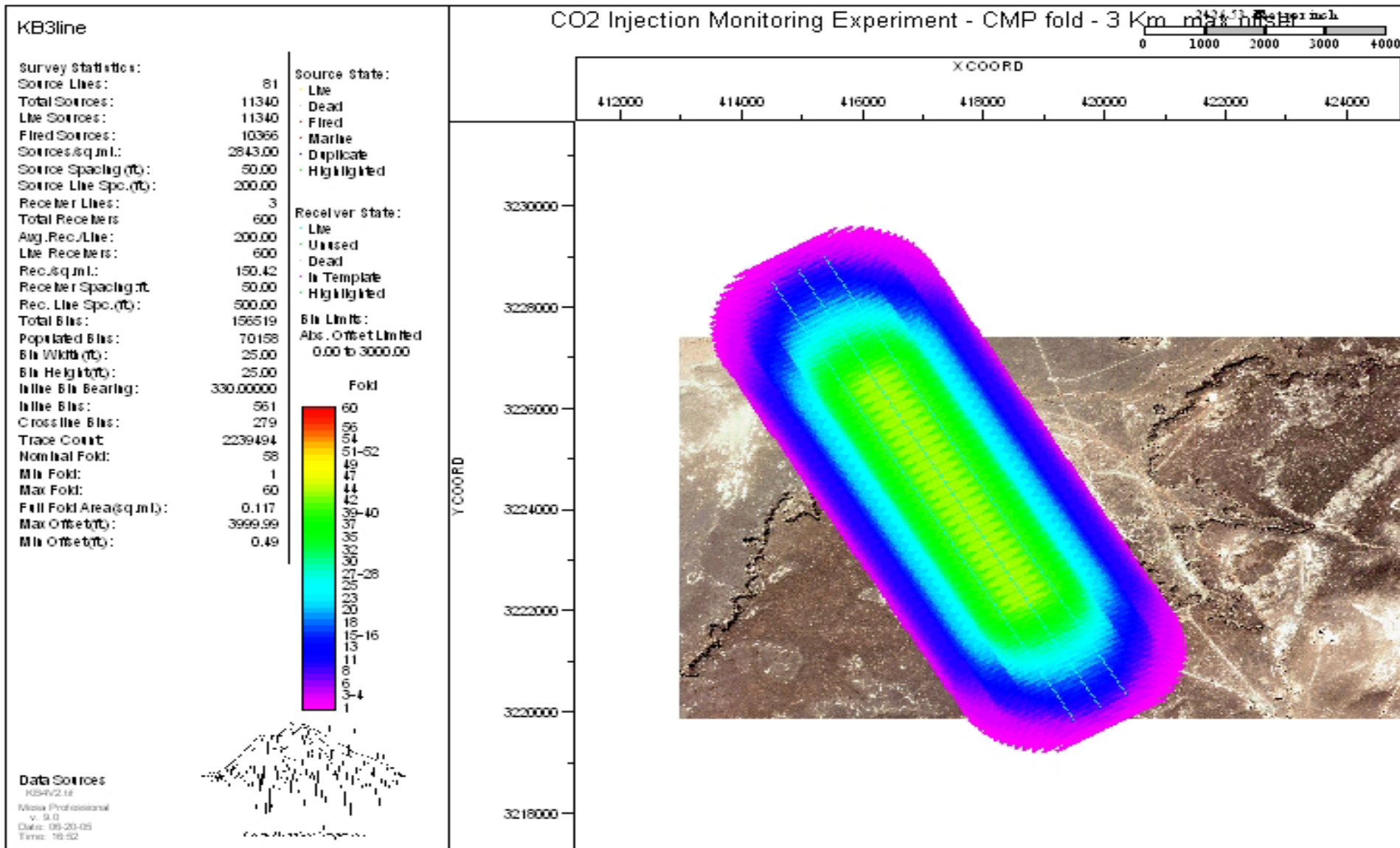
Seismic Vibrosis Truck



Seismic Sources/Receivers



Seismic Data Spread



Summary



- **On-stream August 2004, selling 900 mmscf/d gas into Europe**
- **Compressors, pipelines and three CO₂ injection wells complete**
- **Incremental CCS Investment:**
 - **CCS Capex = \$100mm to store 17mm tonnes CO₂**
 - **With Lifetime Opex, Cost = \$8 /tonne CO₂ (no economic benefit)**
- **Storing 1mmtpa CO₂ = UK wind = ¼ million cars off the road**
- **Storage assurance program commencing**
- **Storage assurance JIP being formed**
 - **Application for part-funding within EU FP-6 (CO₂ ReMoVe)**
 - **Application for CSLF Approval**

Questions ?

