Pressure Management for Improved CO_2 Storage Capacity and Security

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5th International Workshop on Offshore Geologic CO2 Storage organised by GCCC, BEG at the University of Texas, with IEAGHG, New Orleans, USA, 19-20 May 2022

Outline

- Storage Capacity Constraints
- Offshore Examples from Mature Hydrocarbon Basins
  1) Plume Migration
  2) Pressure Footprint
- Managed Pressure
  3) CO_2 Replaces Waterflood towards end of Field Life
  4) Brine Production

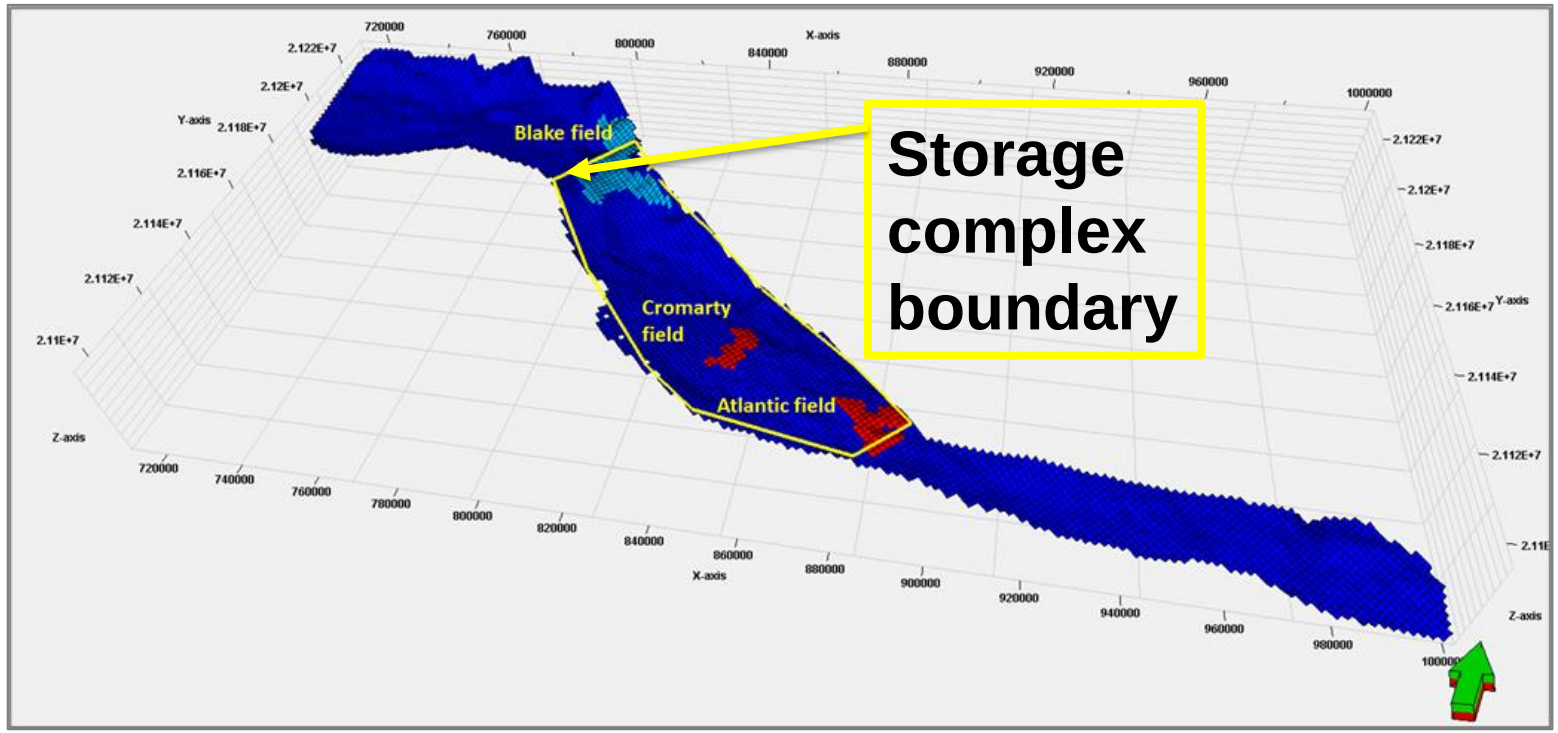
Storage Capacity

Constrained by ability to manage

1. **Migration**
   - CO_2 must remain within storage complex boundaries (for X thousand years)
2. **Pressure**
   - Seals must not fail
     - » Caprock
     - » Faults
     - » Wells

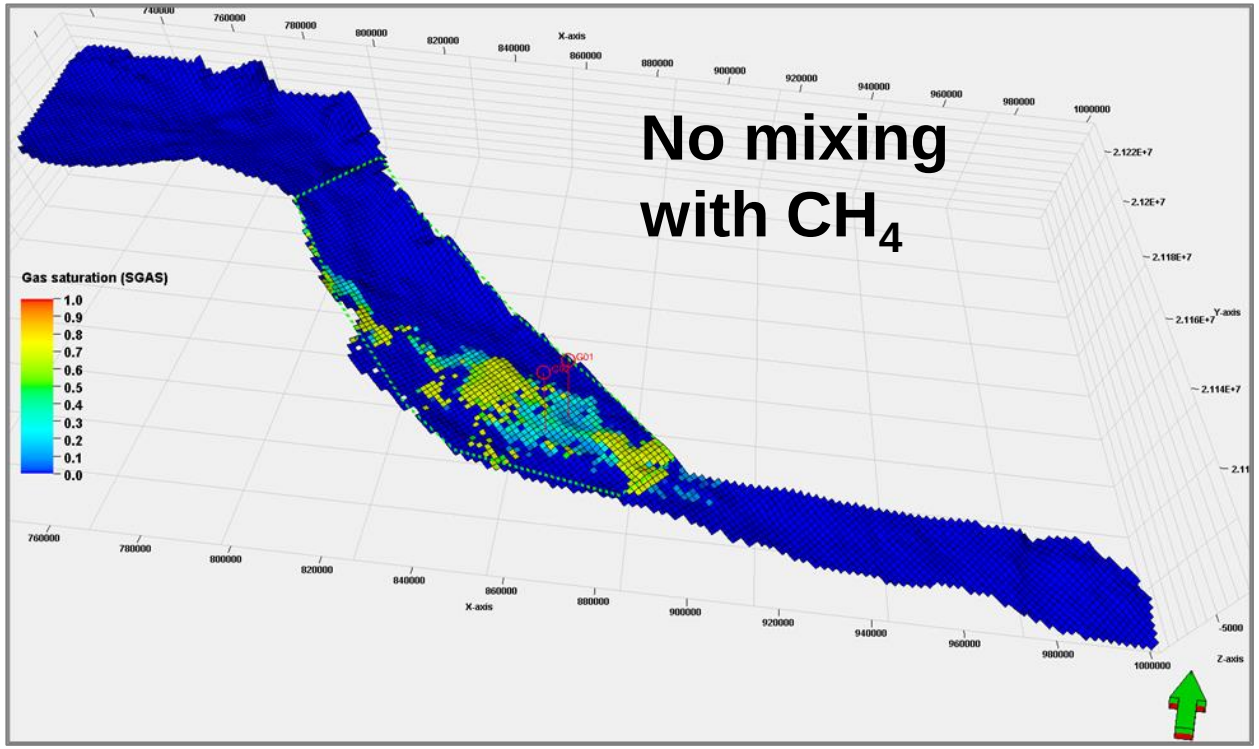
Offshore Example from Mature Hydrocarbon Basins: **1) Plume Migration**

- Captain Aquifer has various active and abandoned O&G fields
- Calculate propagation of plume if CO_2 invades a depleted gas field, and compare with situation if no gas initially present

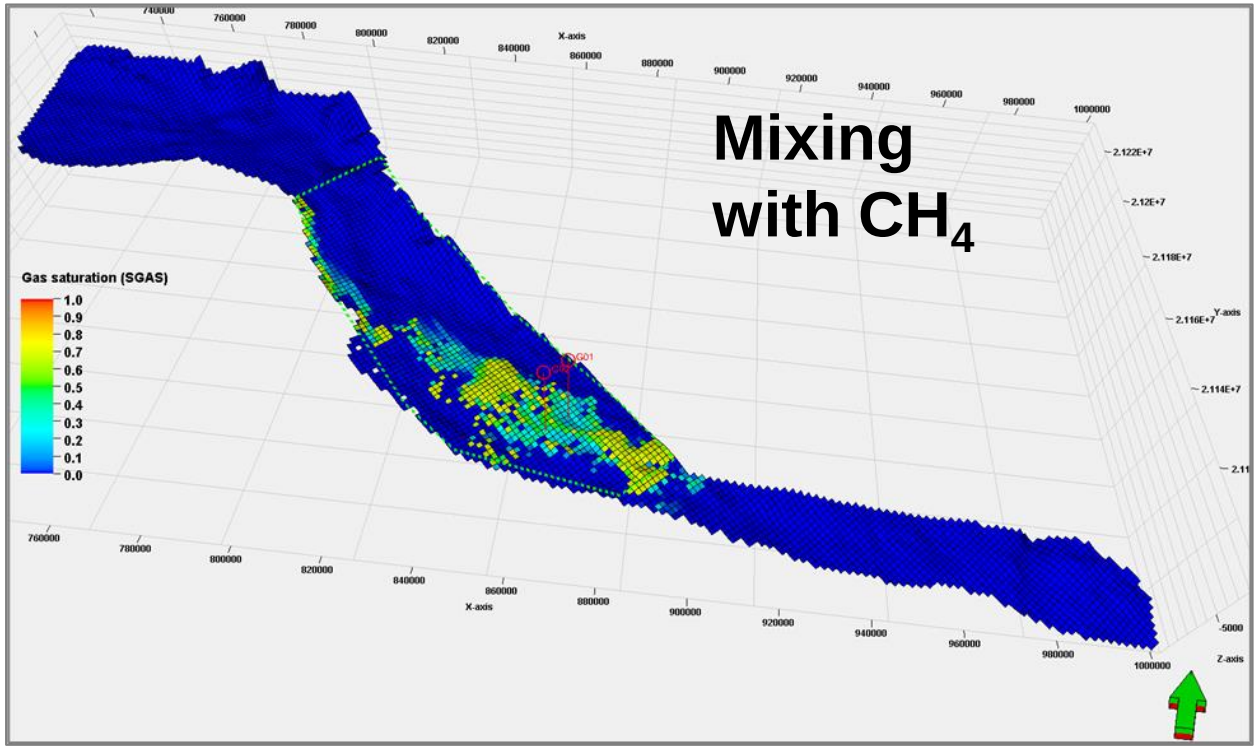


Ghanbari et al. (2020) *"Impact of CO2 Mixing with Trapped Hydrocarbons on CO2 Storage Capacity and Security: A Case Study from the Captain Aquifer (North Sea)"*

Time for Plume to Reach Storage Complex Boundary

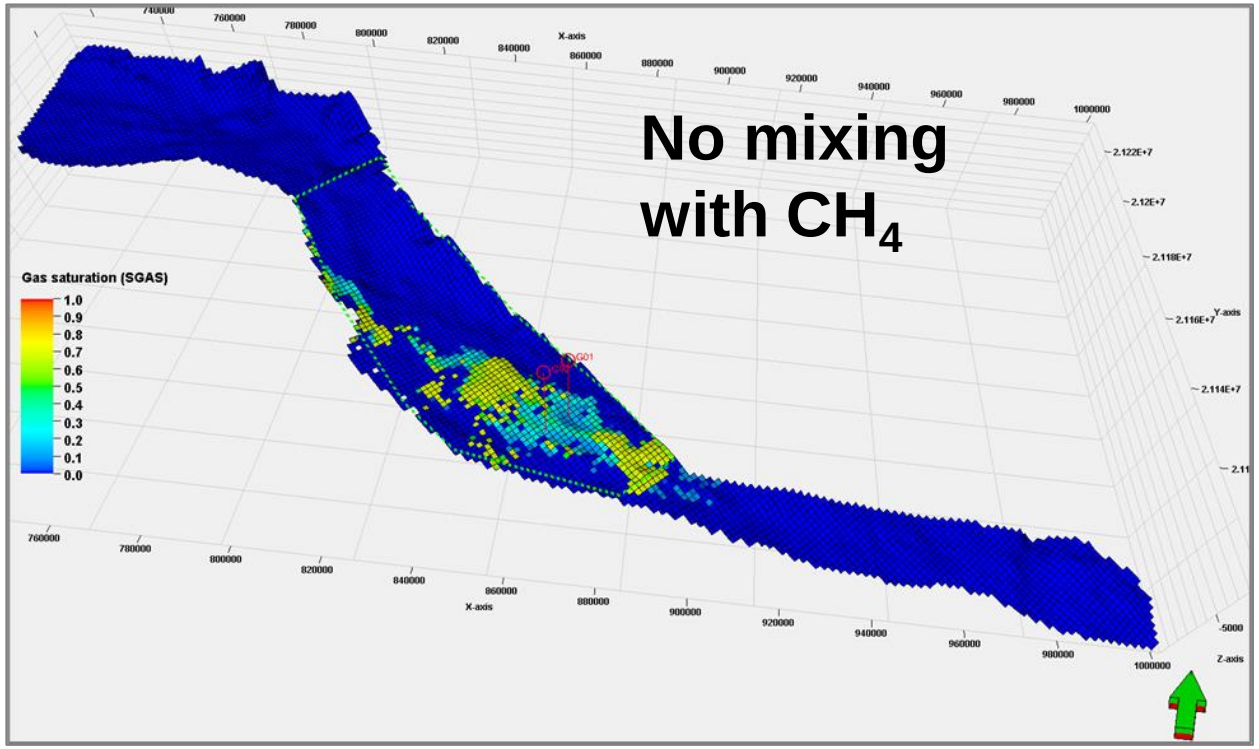


1000 years after injection

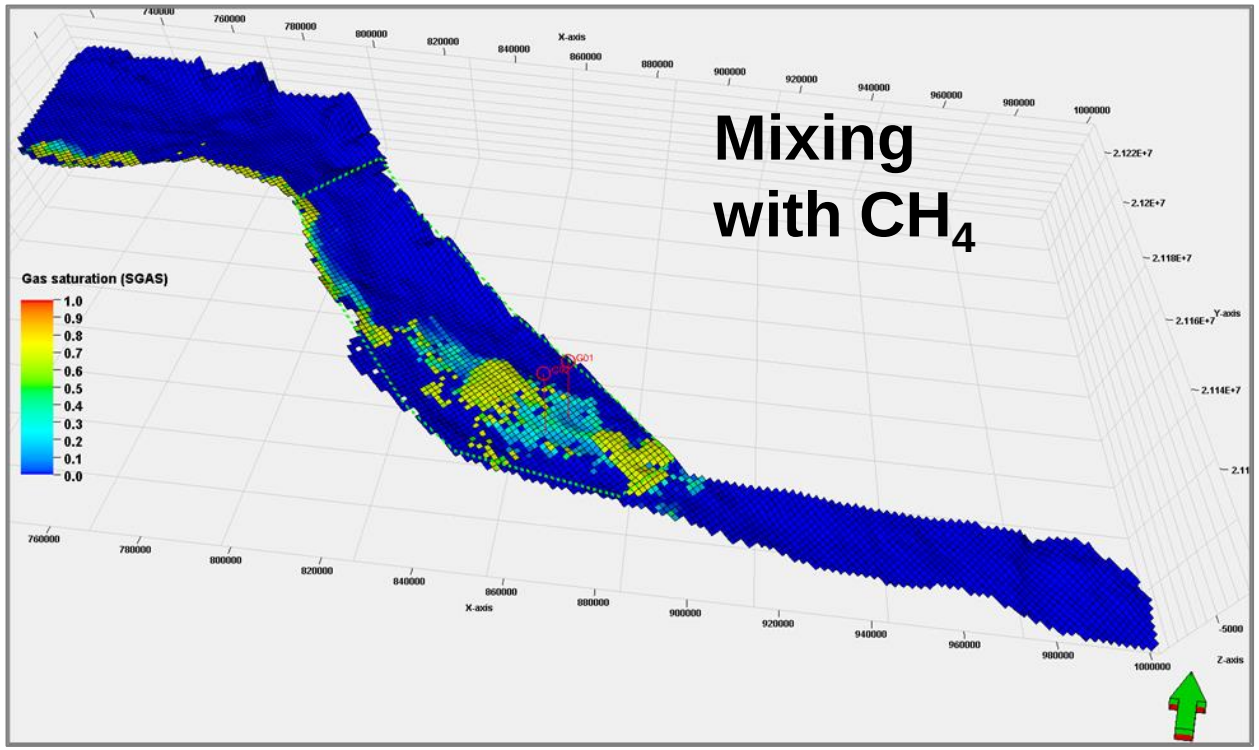


300 years after injection

Final Plume Location

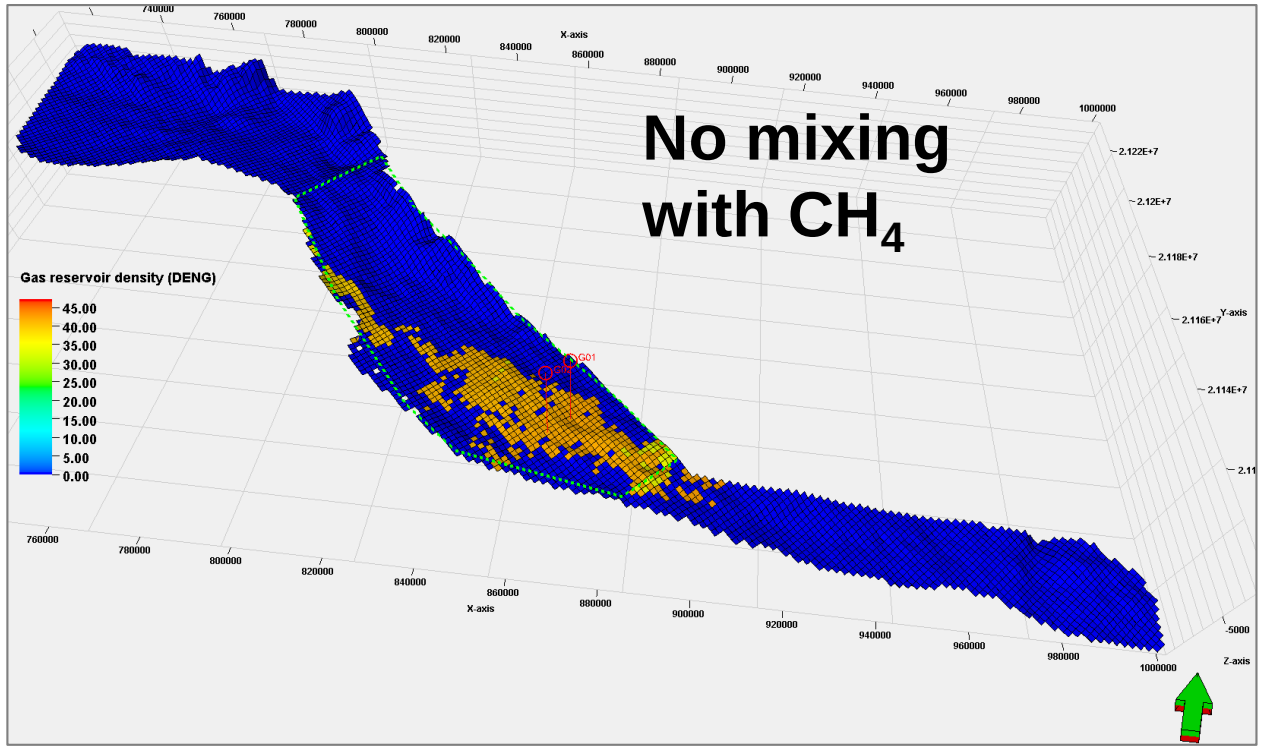


1000 years after injection

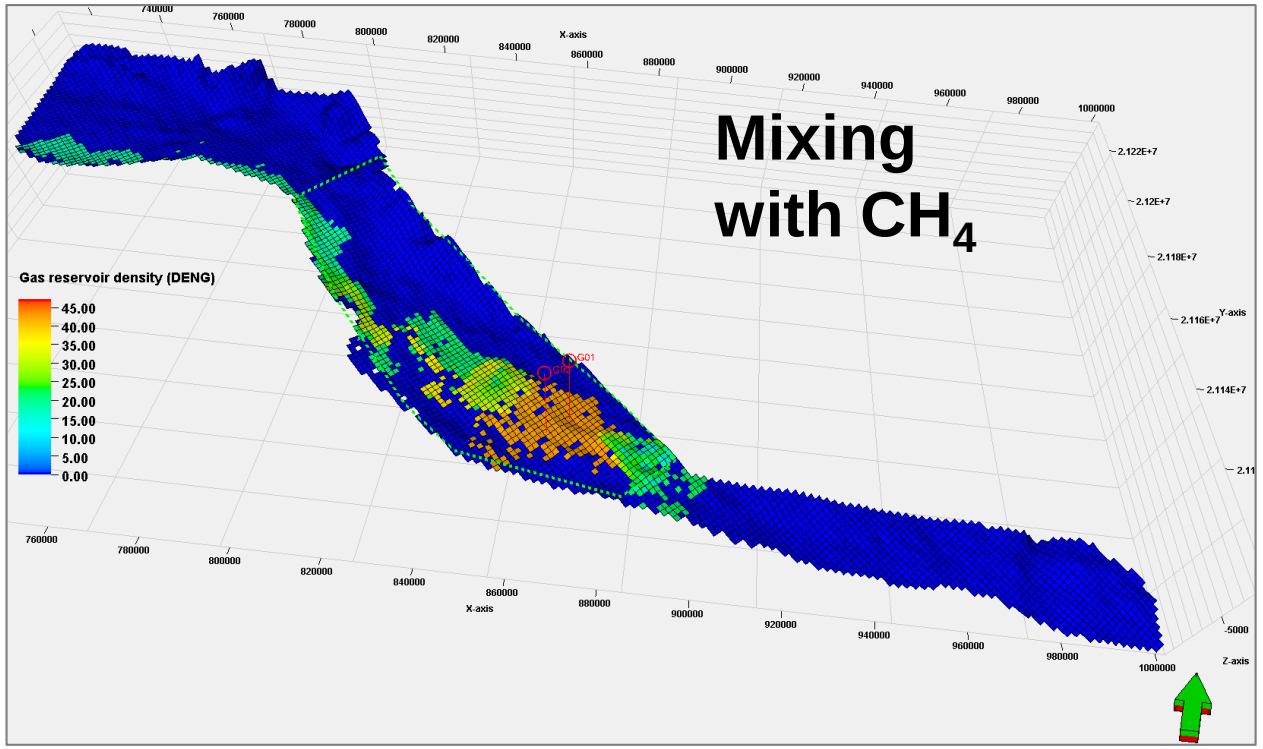


1000 years after injection

Plume Gas Densities



1000 years after injection



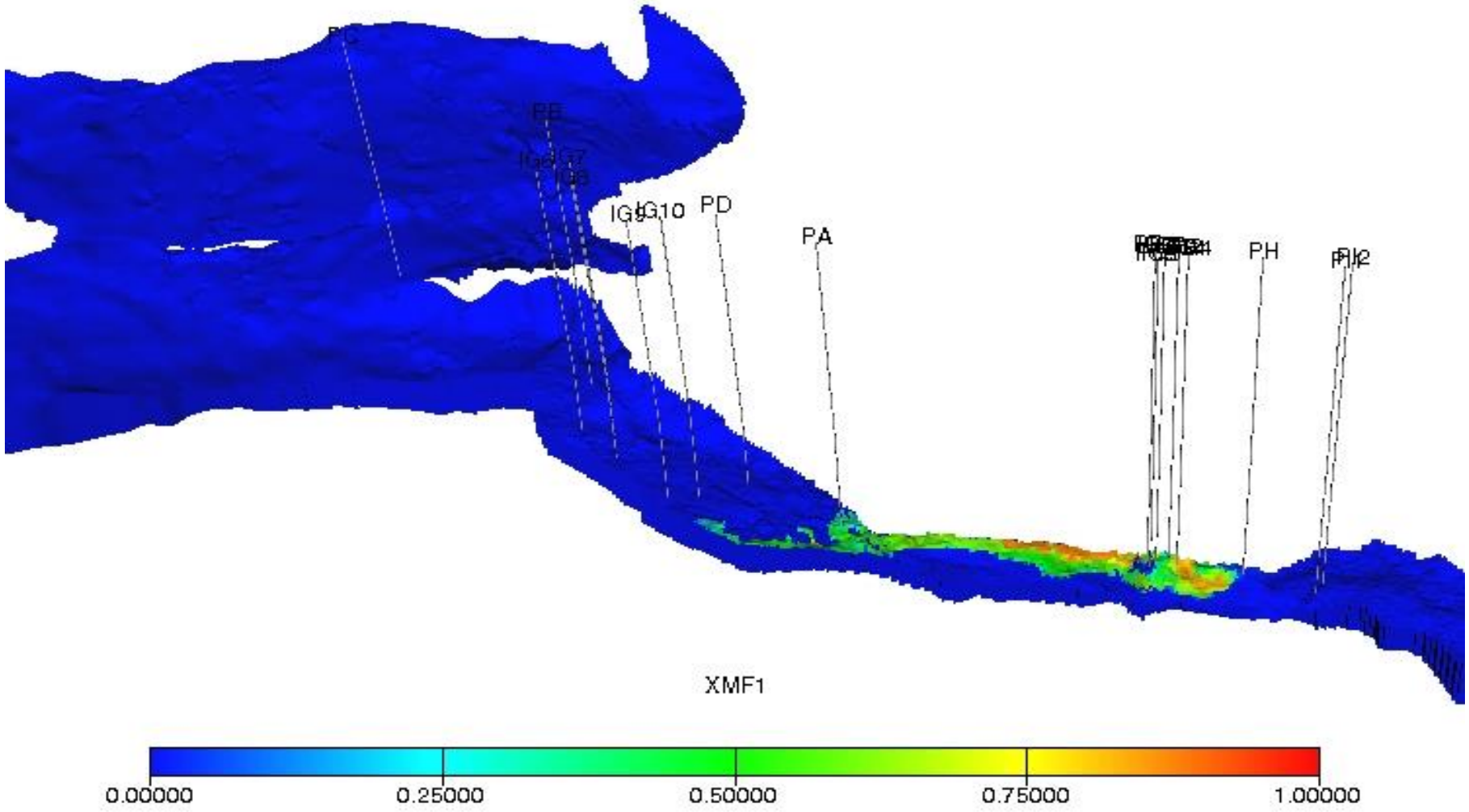
1000 years after injection

Why does CO_2-CH_4 Mix Migrate Faster?

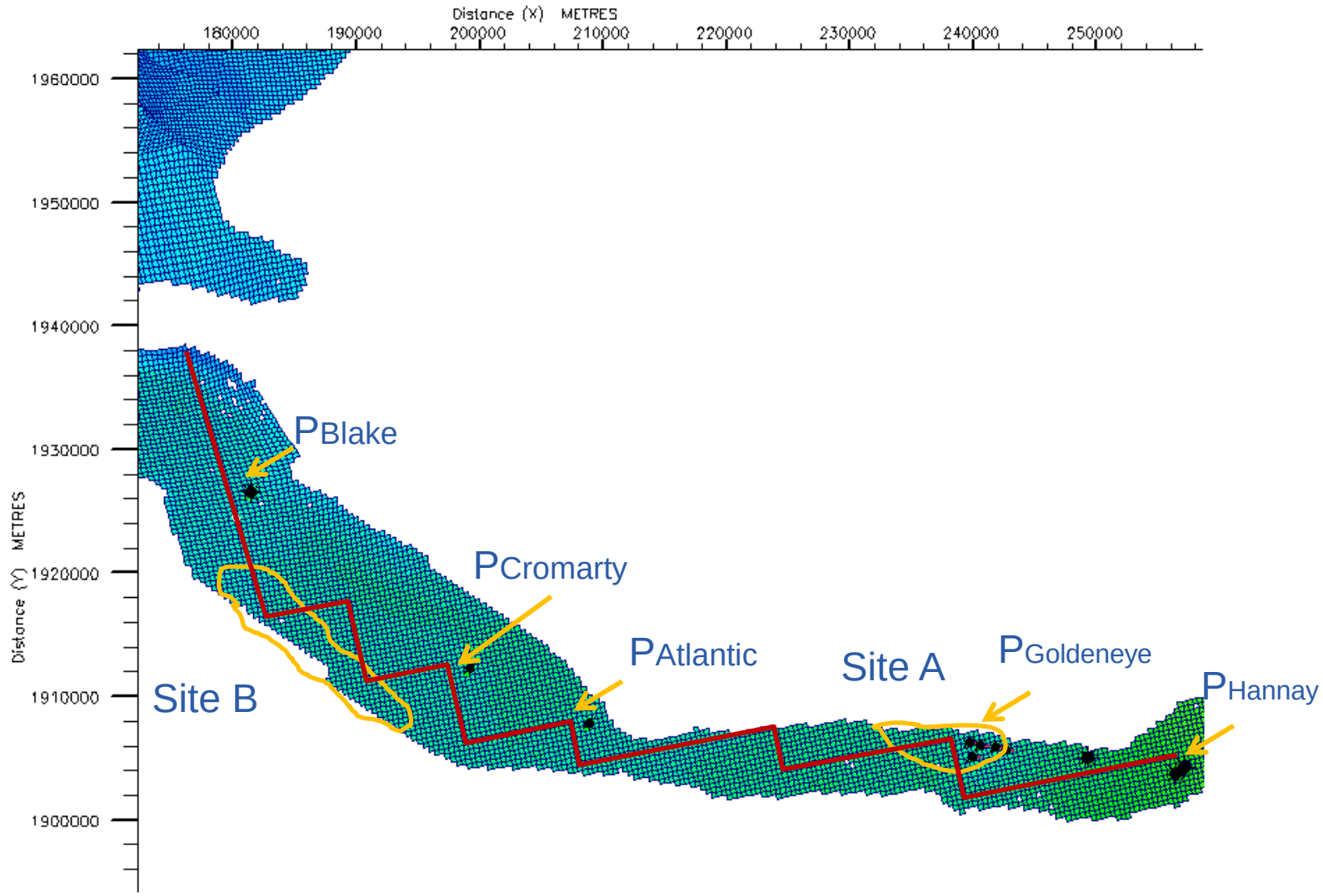
Methane (compared to CO_2)

- less dense
  - mixture more buoyant
- less viscous
  - mixture more mobile
- does not dissolve in brine
  - CO_2 subject to dissolution, so migration retarded by residual *and* dissolution trapping
  - CH_4 is not soluble in brine, so migration *only* retarded by residual trapping

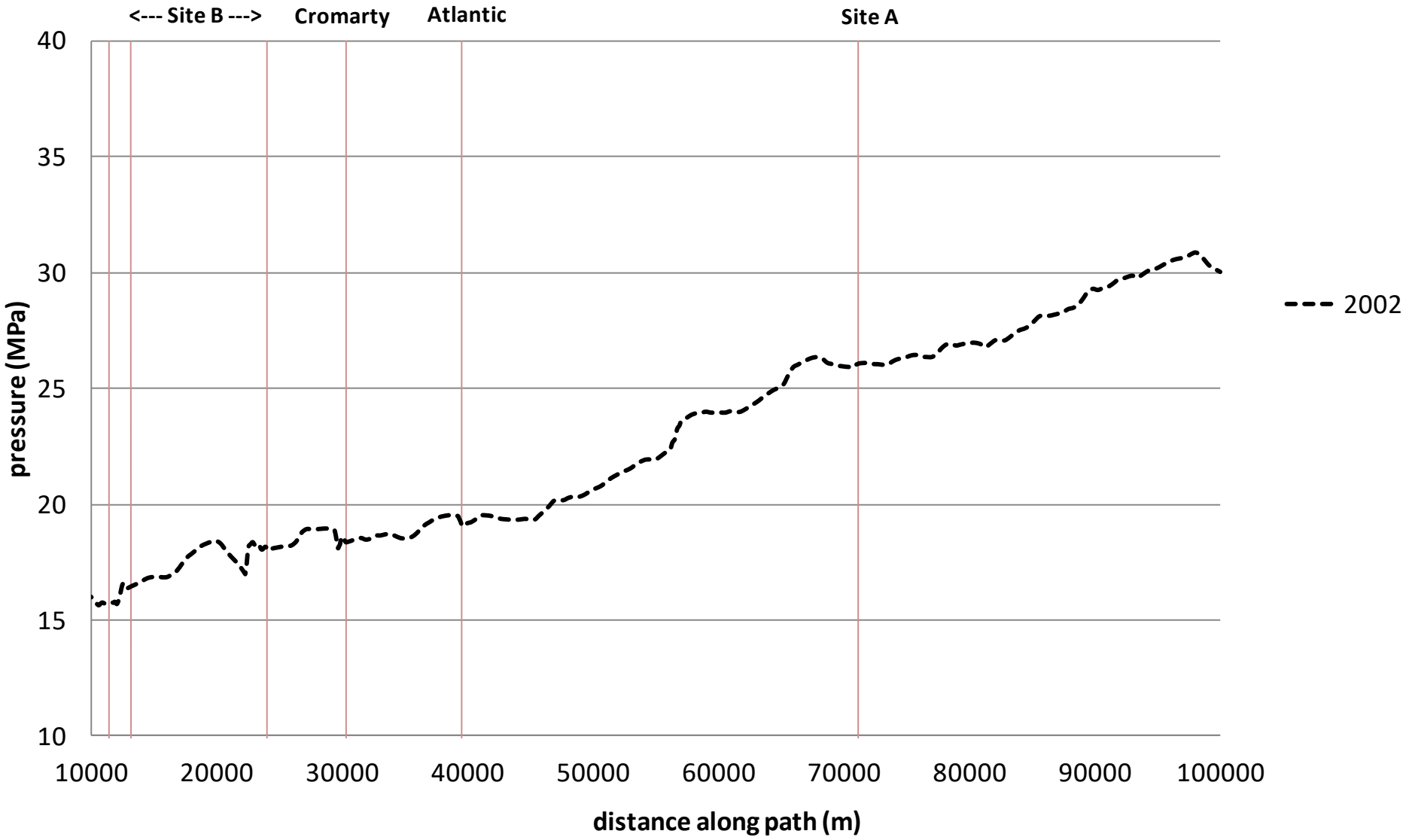
Offshore Example from Mature Hydrocarbon Basins: **2) Pressure Footprint**



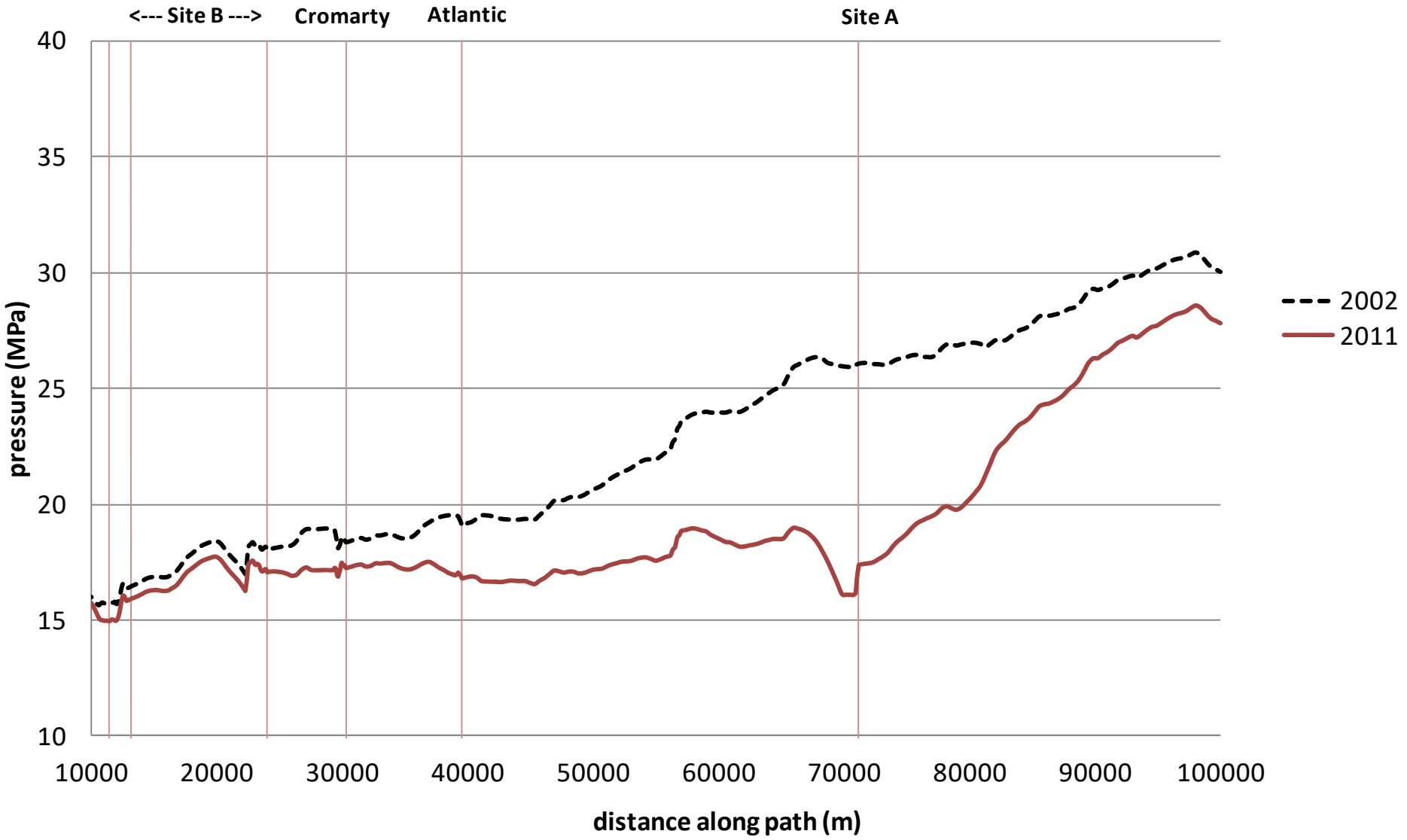
Cross Section for Pressure Profiles



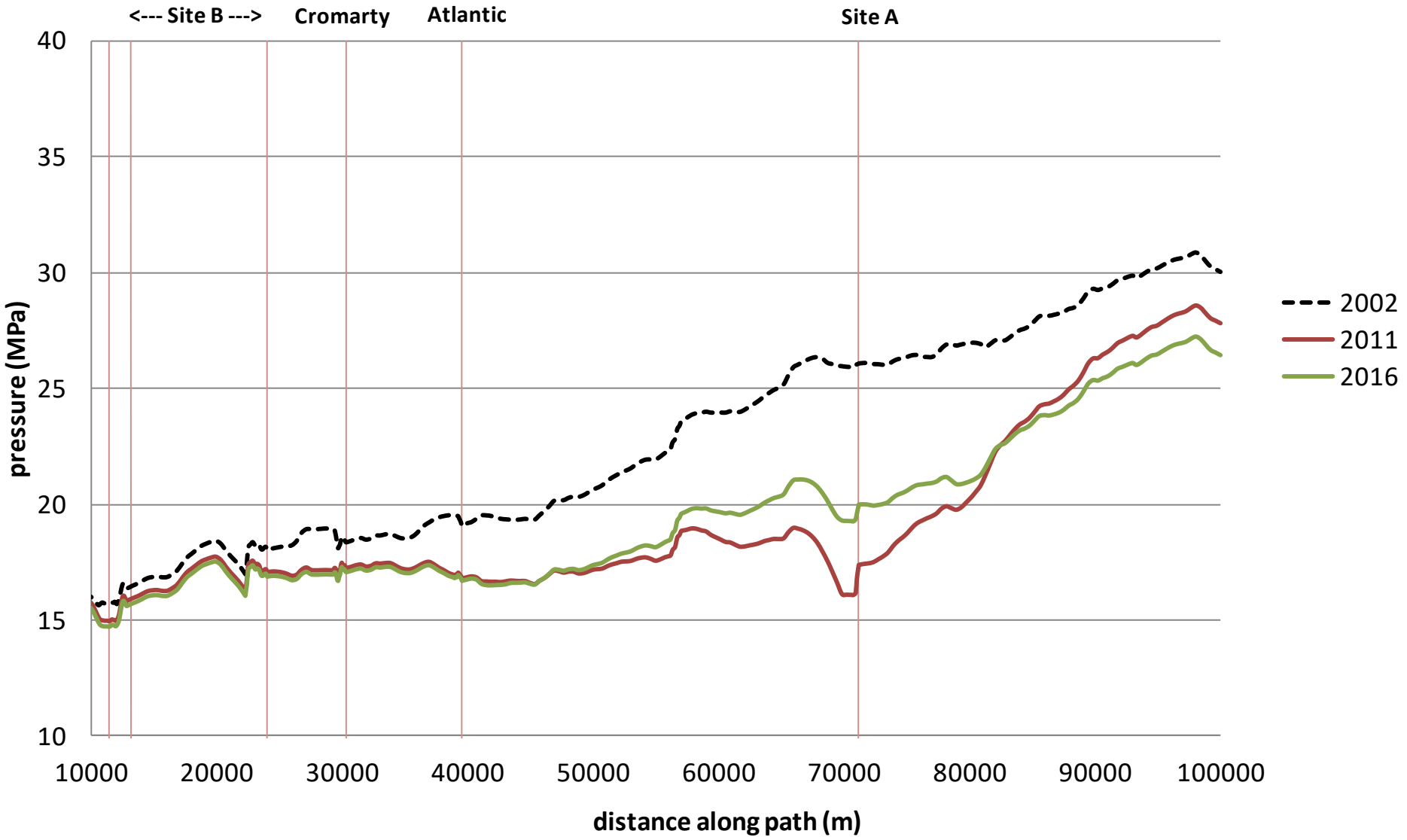
Pressure Profiles for Injection in Goldeneye – Initial Hydrostatic Equilibrium



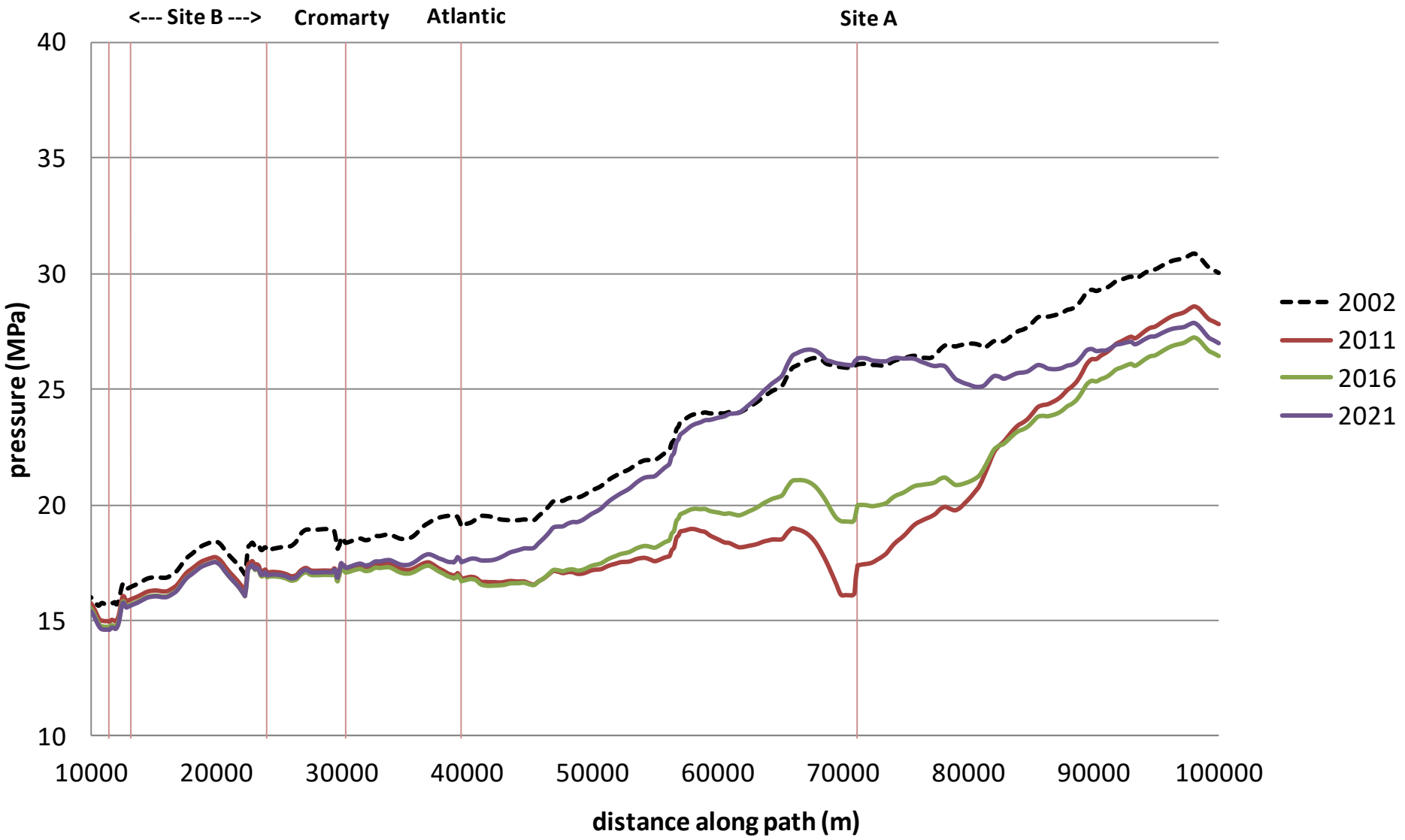
Pressure Profiles for Injection in Goldeneye – After Cessation of Gas Production



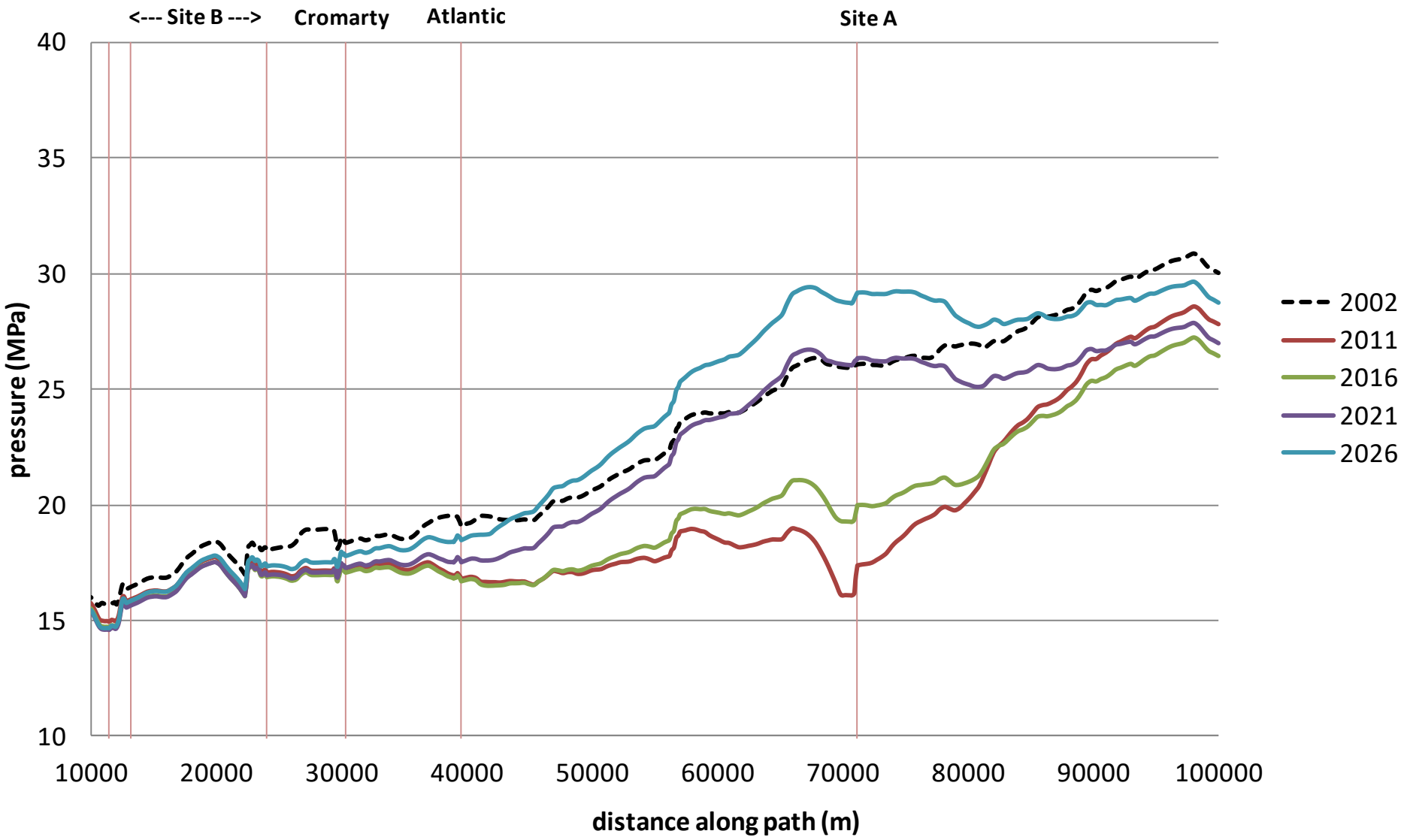
Pressure Profiles for Injection in Goldeneye – After 5 Years of Aquifer Recharge



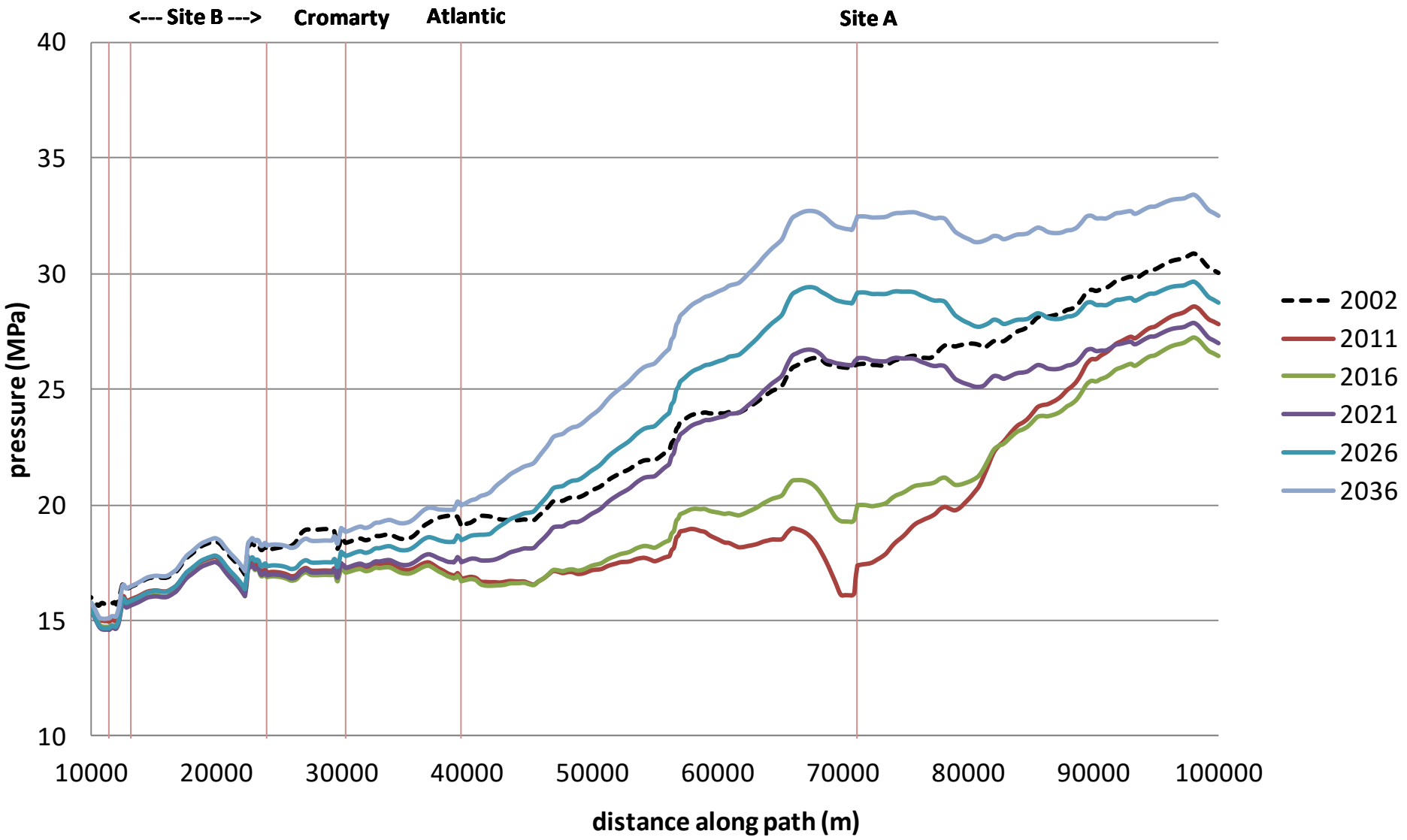
Pressure Profiles for Injection in Goldeneye – After Injection of 30 MT of CO_2



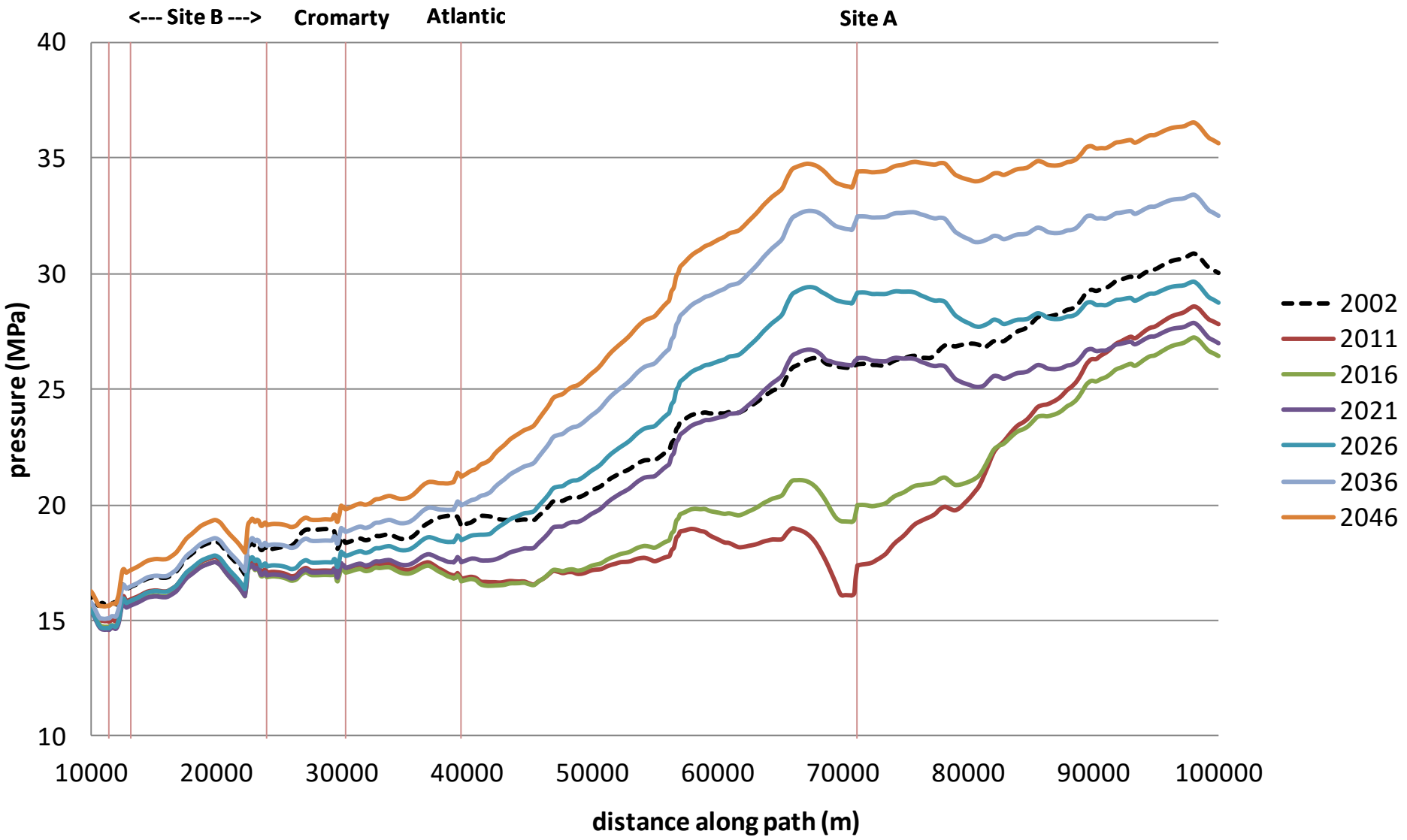
Pressure Profiles for Injection in Goldeneye – After Injection of 60 MT of CO_2



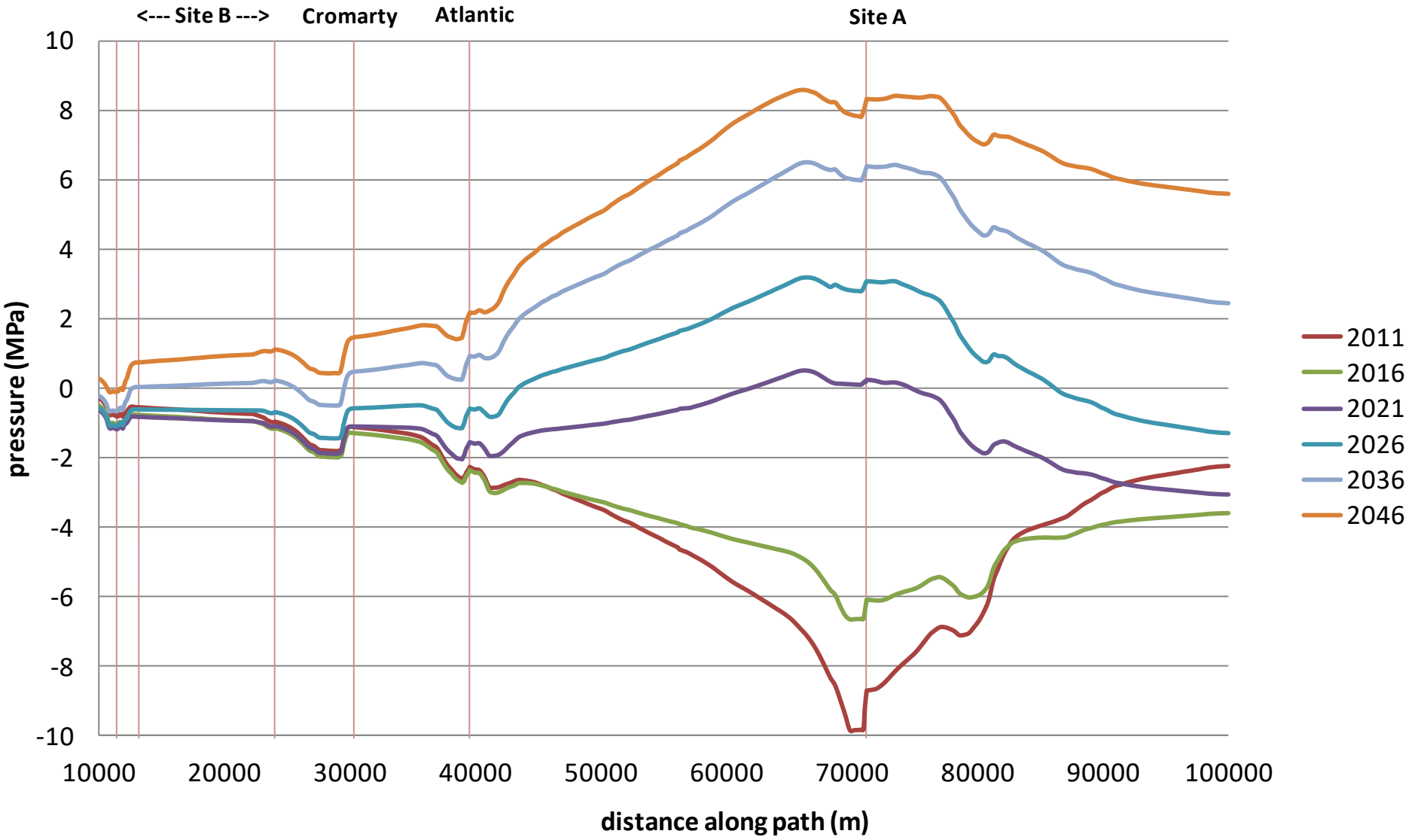
Pressure Profiles for Injection in Goldeneye – After Injection of 90 MT of CO_2



Pressure Profiles for Injection in Goldeneye – After Injection of 180 MT of CO_2



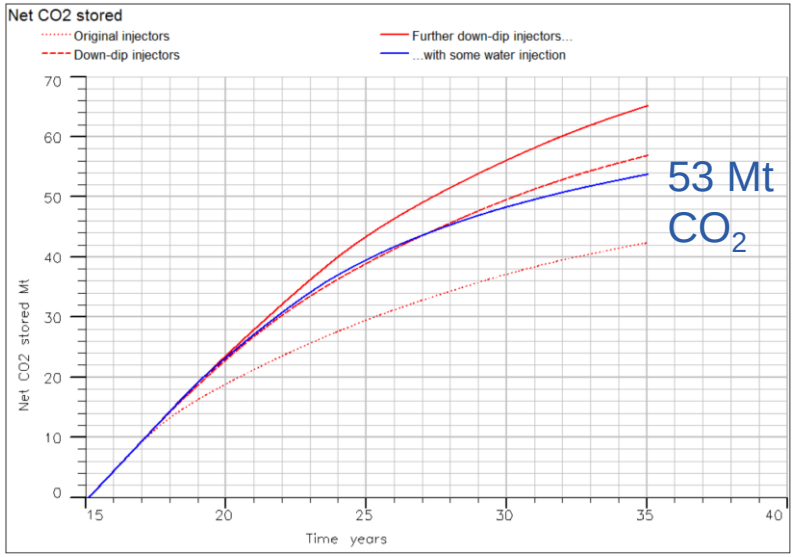
Pressure Differences for Injection in Goldeneye

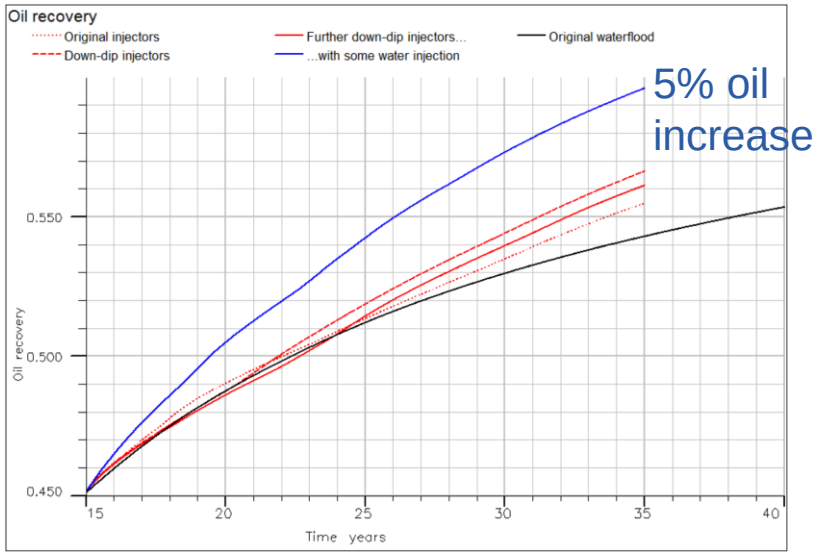


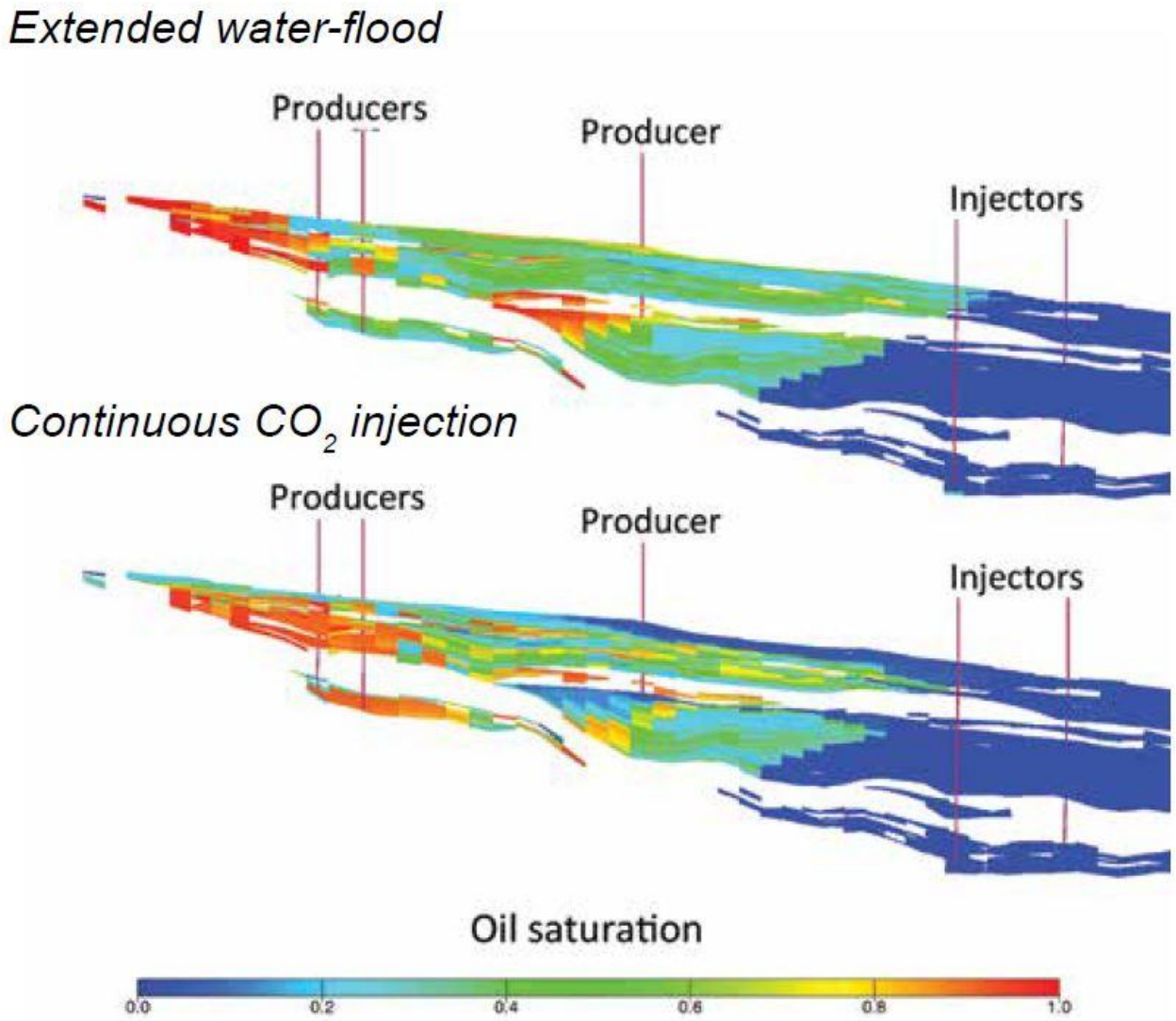
Pressure Footprint

- Natural gas production creates increased storage capacity
  - May be limited by aquifer recharge (time)
- Pressure footprint propagates much faster and further than CO_2 footprint
- Regulators may need to consider pressure footprint as well as extent of CO_2 migration

Offshore Example from Mature Hydrocarbon Basins: **3) CO_2 Replacing Waterflood**

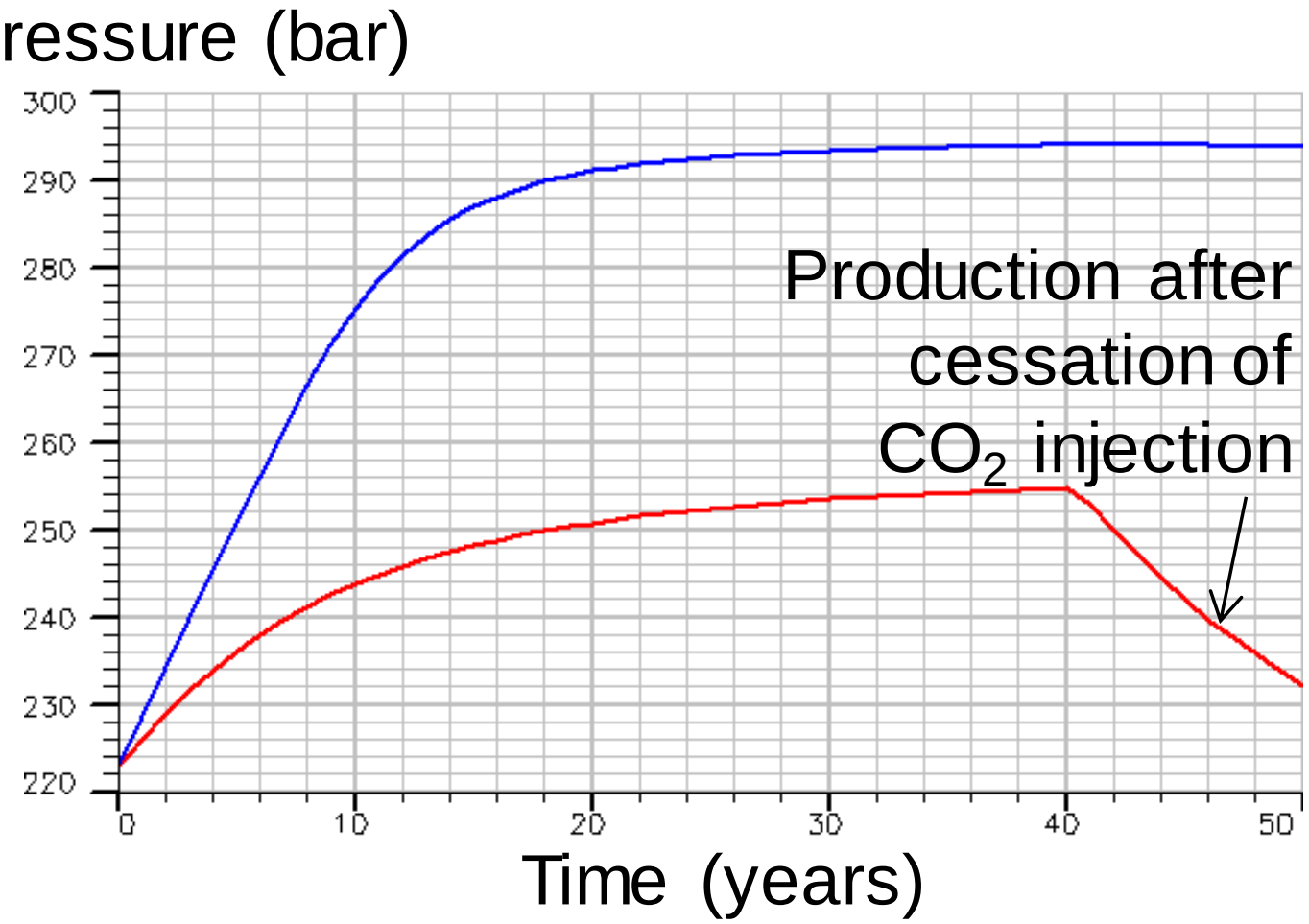






Offshore Example from Mature Hydrocarbon Basins: **4) Brine Production**

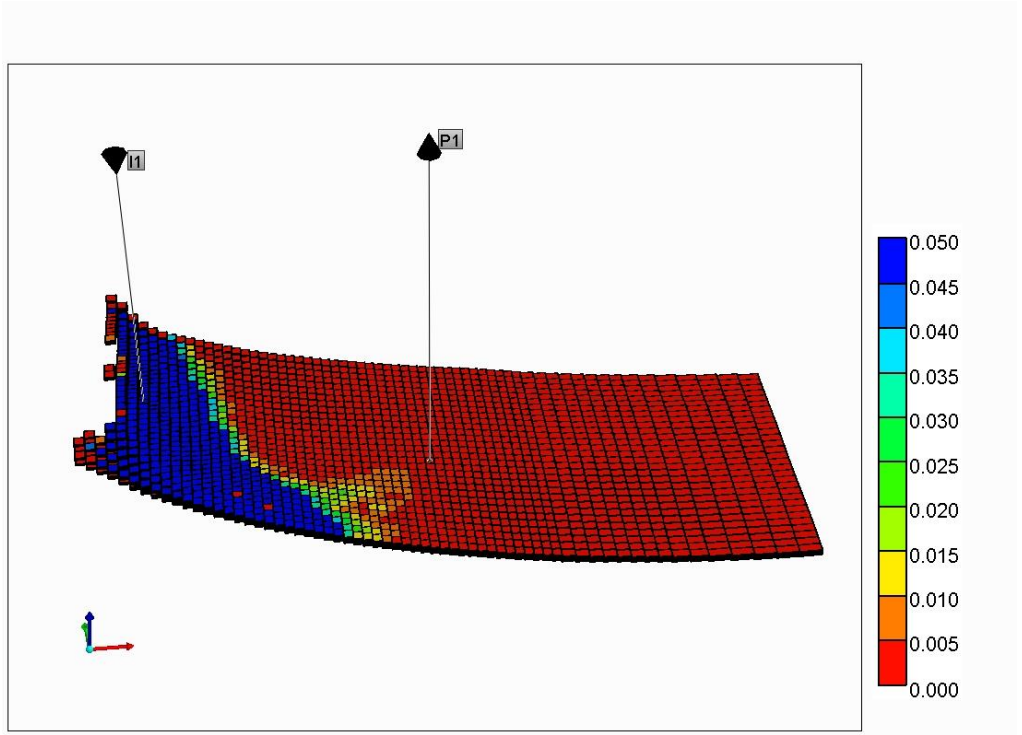
- Up to 4x increase in storage capacity possible
- May be used to reduce pressure after end of CO_2 injection, improving storage security

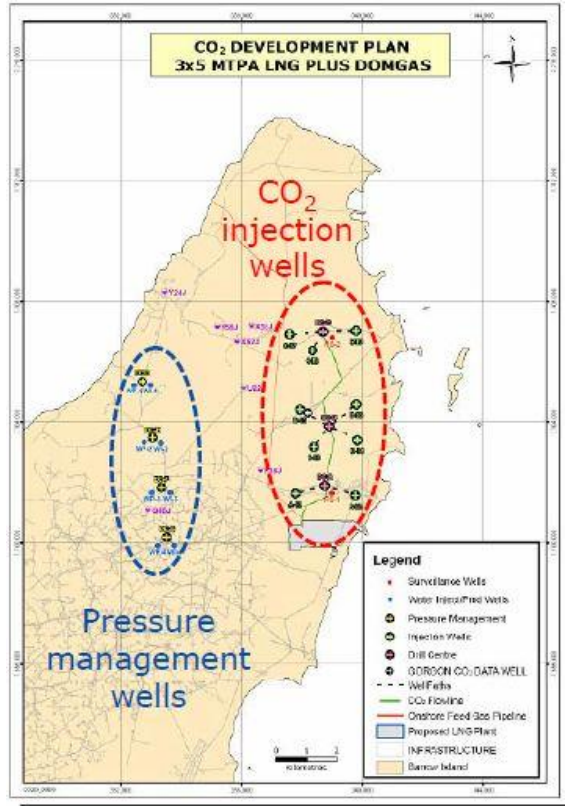


www.sccs.org.uk/progress-to-co2-storage-scotland

Brine Production for Pressure Management

- Optimise well locations to
  - Maximise pressure "support"
  - Minimise risk of CO_2 breakthrough
- Used in Gorgon





www.chevronaustralia.com/ourbusinesses/gorgon

Brine Production – Cost Benefit Analysis

Maximum CO_2 storage capacity (Mt)

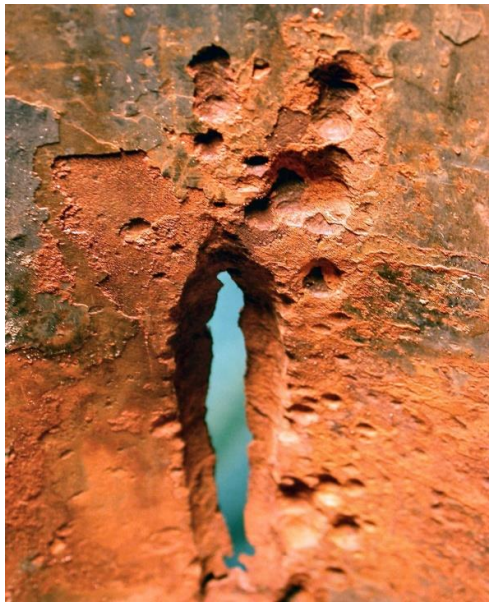
	Brine production			
	No	Yes	% increase in capacity	
Forties 5	400	450	13%	Benefit
Bunter_zone4	200	200	0%	
Tay	150	450	200%	Benefit
Firth of Forth	100	300	200%	Benefit
Bunter Closure 36	50	200	300%	Benefit

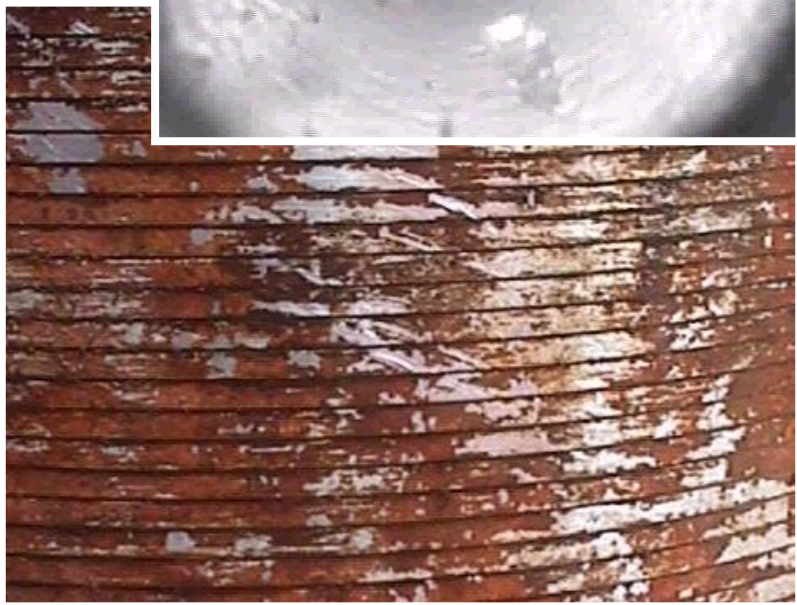
Case study		Total cost saving (undiscounted)	Reduction in levelised cost of Transport & Storage (T&S)
1	Increasing storage capacity of an attractive storage unit	~£1 billion	~£5/tCO2
2	Increasing injection rate to accommodate new emitters	~£0.5 billion	~£2/tCO2
3	Increasing storage duration after 10 years of injection without brine production	~£1 billion	~£6/tCO2
4	Improving performance of an aquifer, which does not perform as expected	~£0.1 billion	~£1/tCO2

- Analogous to brine injection in O&G recovery
- Not always beneficial, but useful tool
- Has challenges

Challenges with Brine Production

- Cost of wells
- Sand production
- Mineral scaling
- Corrosion
- Water treatment and disposal





Thank You

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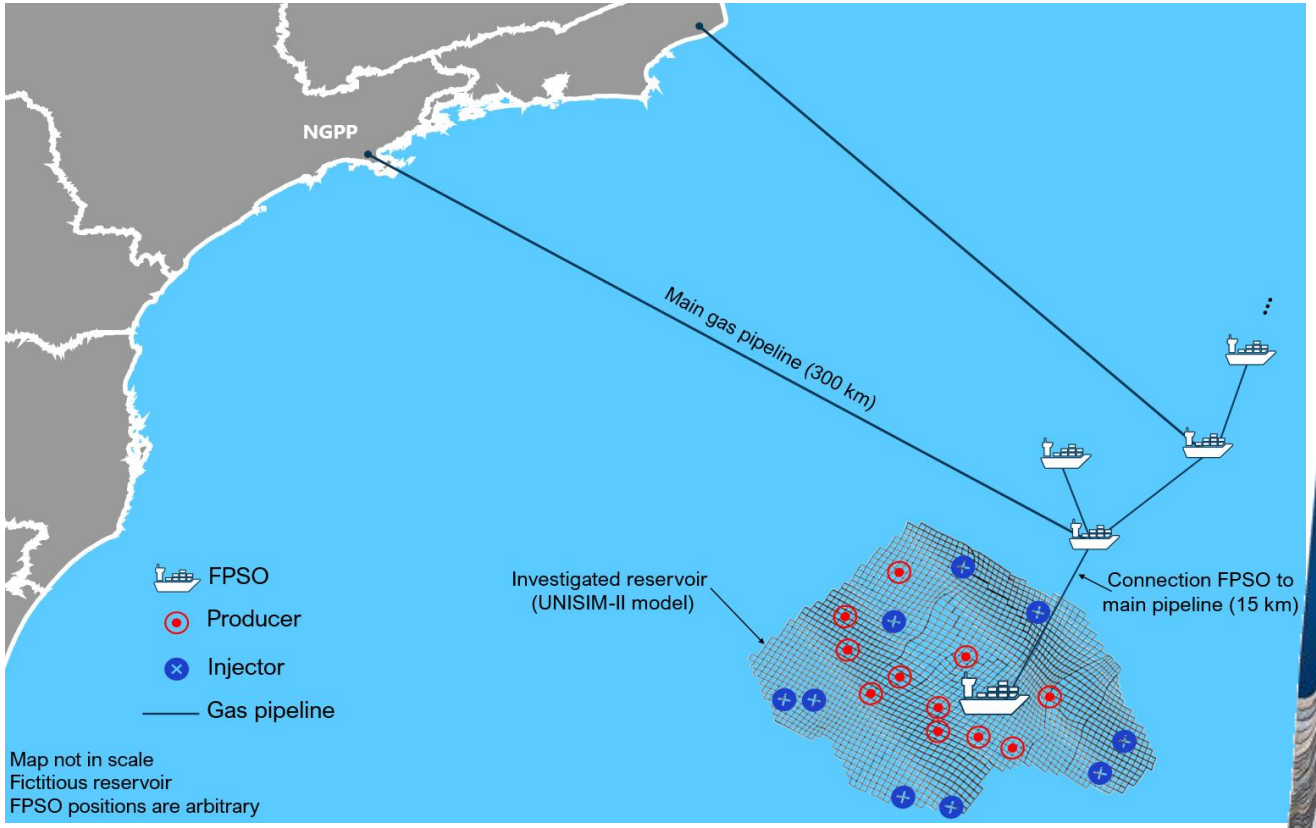
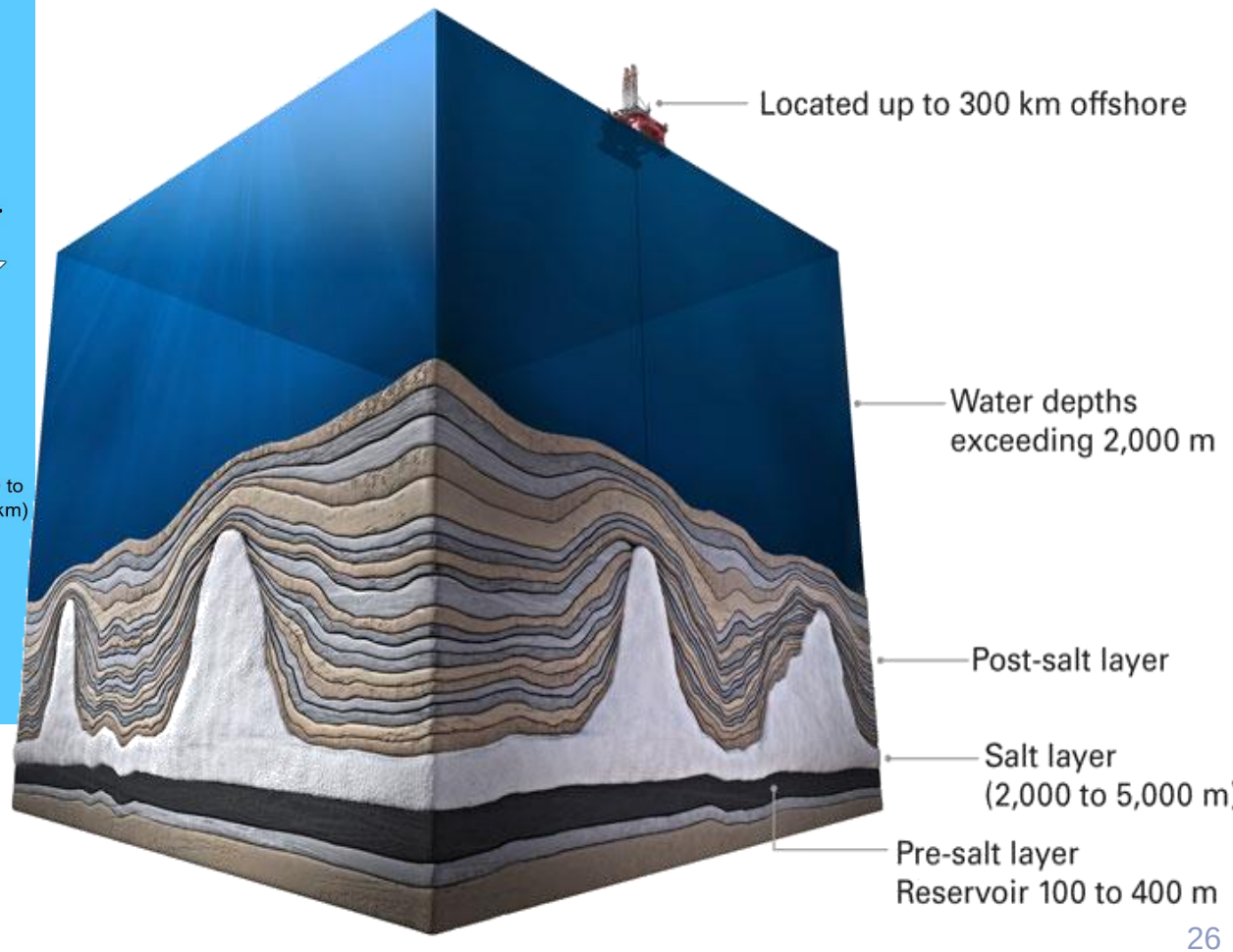
Offshore Example from Mature Hydrocarbon Basins: CO_2 EOR in Pre-Salt





CO_2 EOR: Optimise CO_2 Storage and Maximise Economic Recovery