

# EnergyINet

**CSLF – September 29, 2005**

**Malcolm Wilson**

**Energy INet and University of Regina**

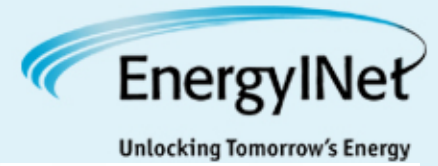
**September, 2005**



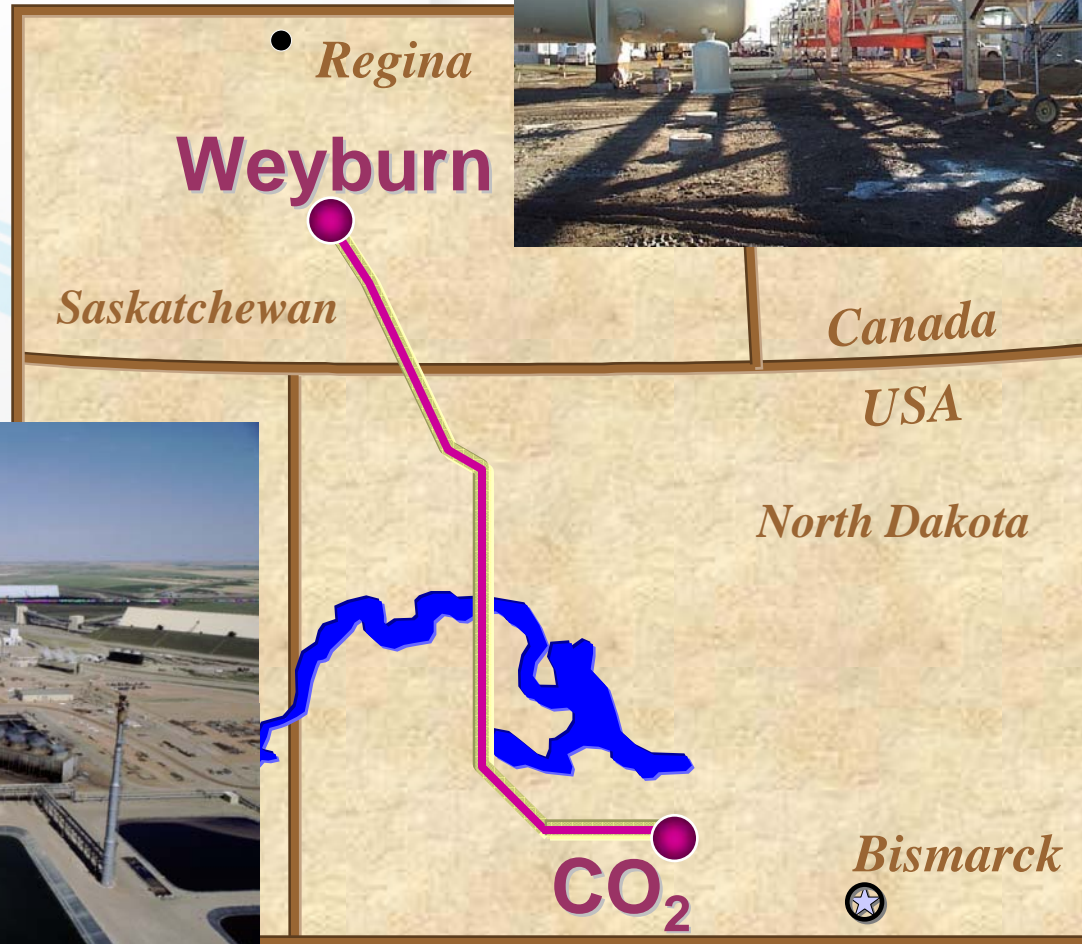
**UNIVERSITY OF  
REGINA**

[www.energyinet.com](http://www.energyinet.com)

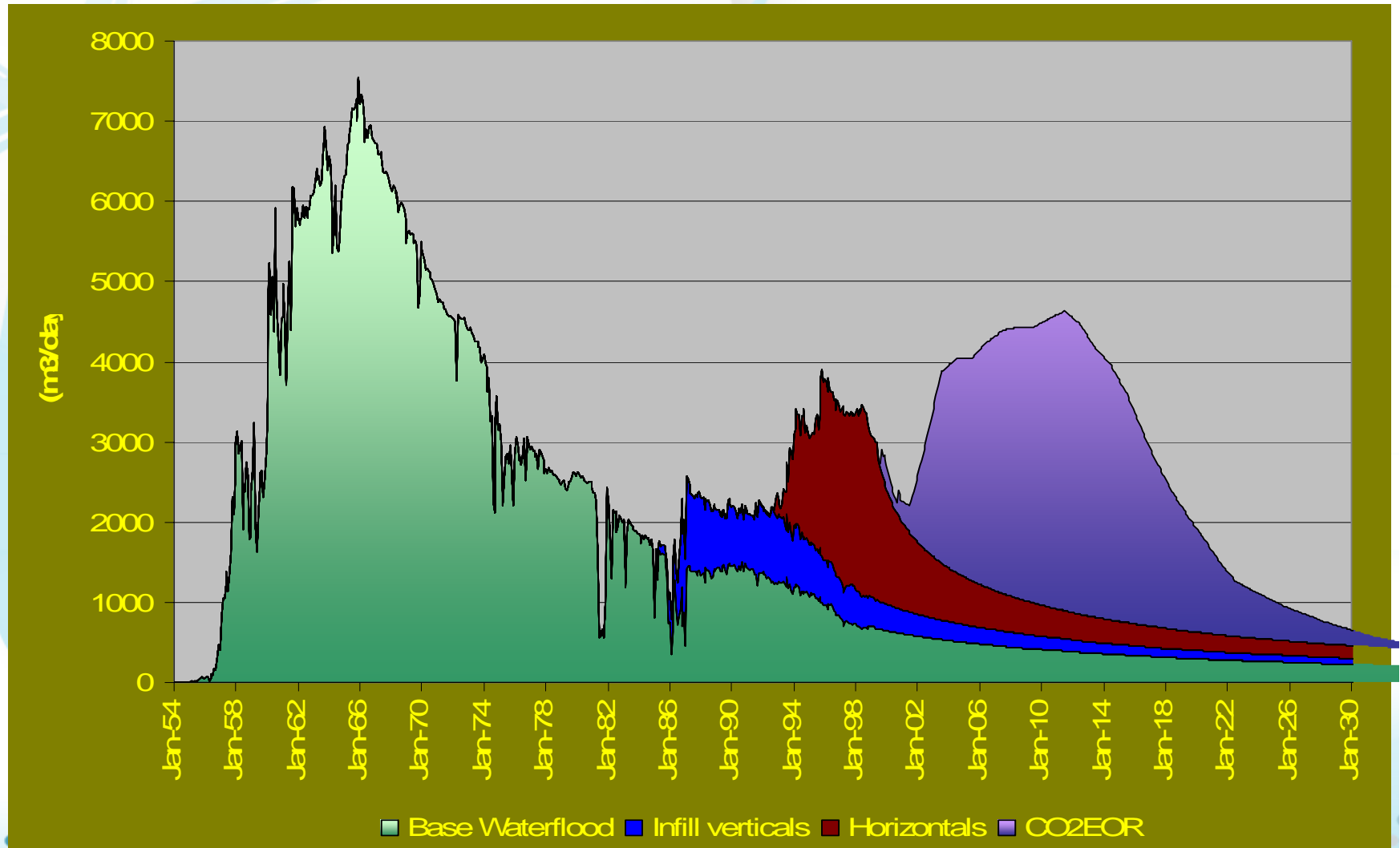
# PROJECT LOCATION



# CO<sub>2</sub> Supply



# Production Forecast with CO<sub>2</sub> EOR



# 4 Research Themes

## THEME 1

**GEOLOGICAL CHARACTERIZATION OF THE GEOSPHERE AND BIOSPHERE**

## THEME 2

**PREDICTION, MONITORING AND VERIFICATION OF CO<sub>2</sub> MOVEMENTS**

## THEME 3

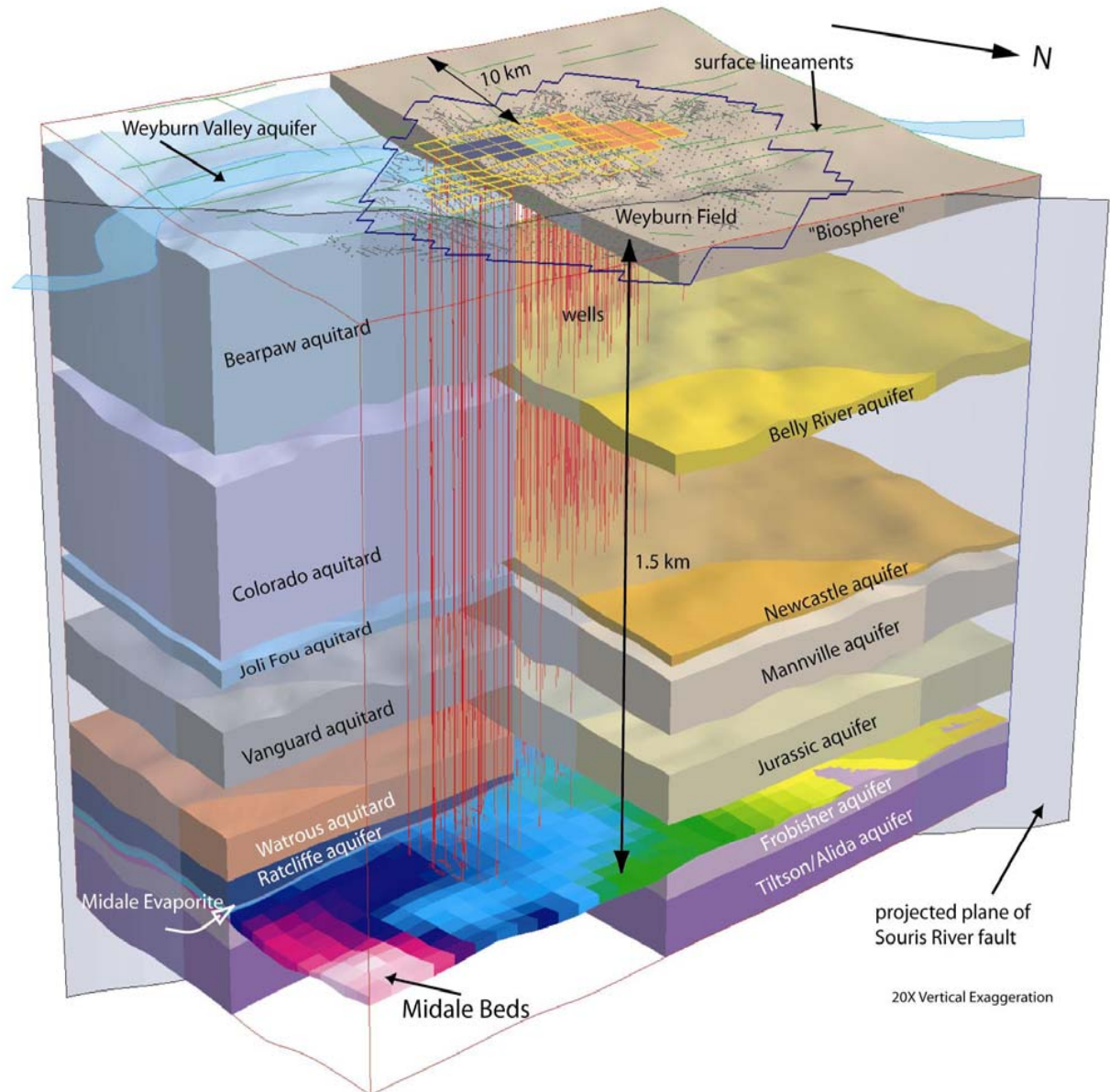
**CO<sub>2</sub> STORAGE CAPACITY AND DISTRIBUTION PREDICTIONS AND THE APPLICATION OF ECONOMIC LIMITS**

## THEME 4

**LONG-TERM RISK ASSESSMENT OF THE STORAGE SITE**

## Geological Model

- ✦ Areal extent 10 km beyond CO<sub>2</sub> flood limits
- ✦ Geological architecture of system
- ✦ Properties of system
  - lithology
  - hydrogeological characteristics
  - faults
- ✦ Can be tailored for different RA methods and scenario analyses



# BIOSPHERE CHARACTERISTICS

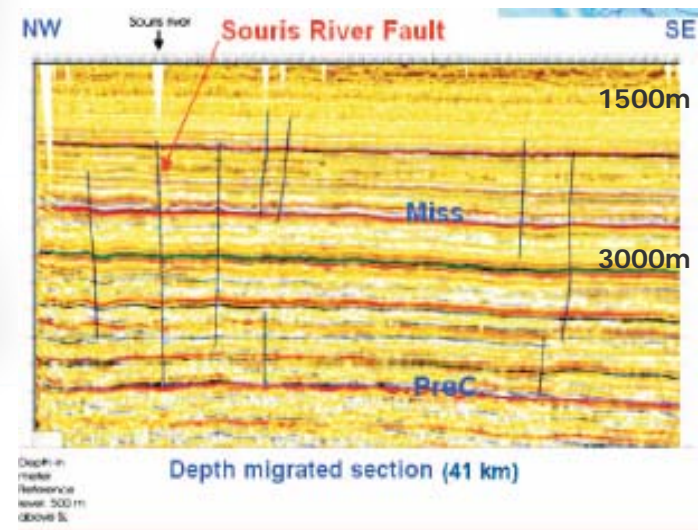
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PERIOD	STRATIGRAPHY			LITHOLOGY	HYDROGEOLOGY	THIS STUDY	
QUATERNARY	Saskatoon Group	Surficial stratified deposits		Gravel, sand, silt, clay	Aquifer	Surficial aquifers	
		Battleford Fm		Till	Aquitard	Undifferentiated Quaternary Aquifers and Aquitards	
		Floral Fm	Upper Till		Till		Aquifer
			Riddell Mb		Stratified deposits		
			Lower Till		Till		
	Sutherland Group	Mennon Fm		Till	Aquitard		
		Dundum Fm		Stratified deposits Till	Aquifer Aquitard		
		Warman Fm		Stratified deposits Till	Aquifer Aquitard		
		Empress Cr	Upper Unit		Gravel, sand, silt, clay - metamorphic, igneous, carbonate rocks	Aquifer	Empress Group Aquifers
			Lower Unit		Gravel, sand, silt, clay - quartzite and chert rocks		
	TERTIARY	Saskatchewan	ND	MT			
Ravenscrag Fm		Ludlow - Golden Valley	Fort Union	Sand, silt, clay, coal	Aquifer	Undifferentiated Tertiary/Cretaceous Aquifer	
Frenchman Fm				Hell Creek			Sand, silt, clay
Battle Fm	Fox Hills	Sand, silt, clay					
Whitemud Fm		Sand, silt, clay					
CRETACEOUS	Eastend Fm			Sand, silt, clay			
	Bearpaw Fm	Pierre Shale			Aquitard	Aquitard	
	Judith River Fm				Aquifer		
	Lea Park Fm Upper Colorado				Aquitard		

BIOSPHERE

## Monitoring Techniques

- 4D, 3C surface seismic
- 4D, 9C surface seismic
- 3D, 3C vertical seismic profile (VSP)
- Cross-well seismic
- Geochemical sampling analysis
- Tracer injection monitoring
- Conventional production data analysis
- Passive seismic

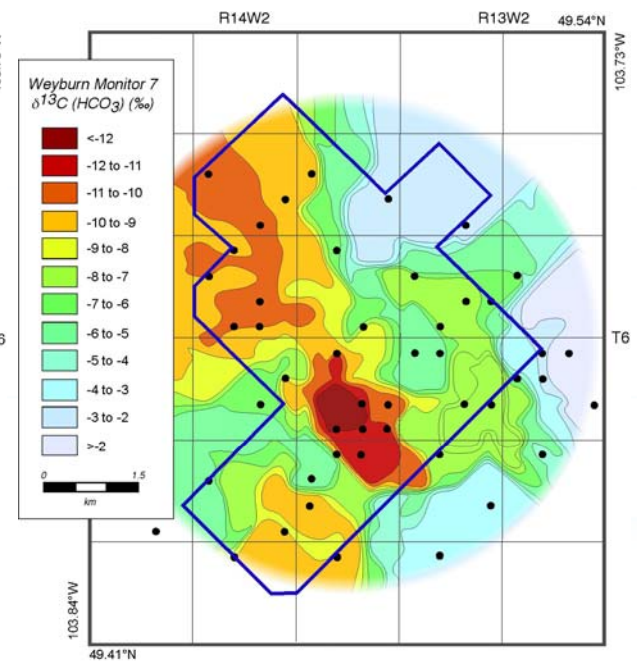
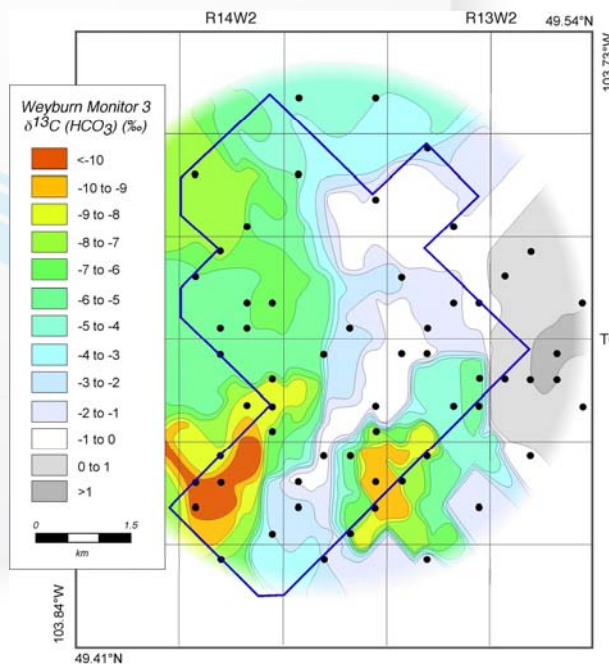
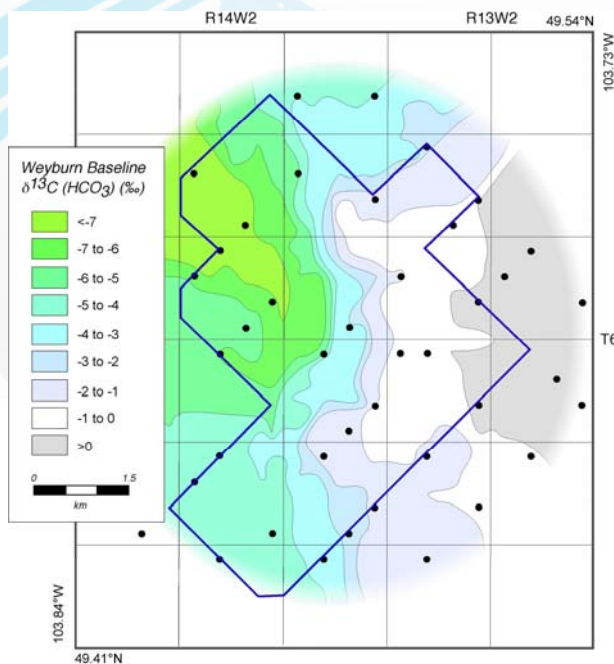




## Pre-injection

## 12 months

## 31 months



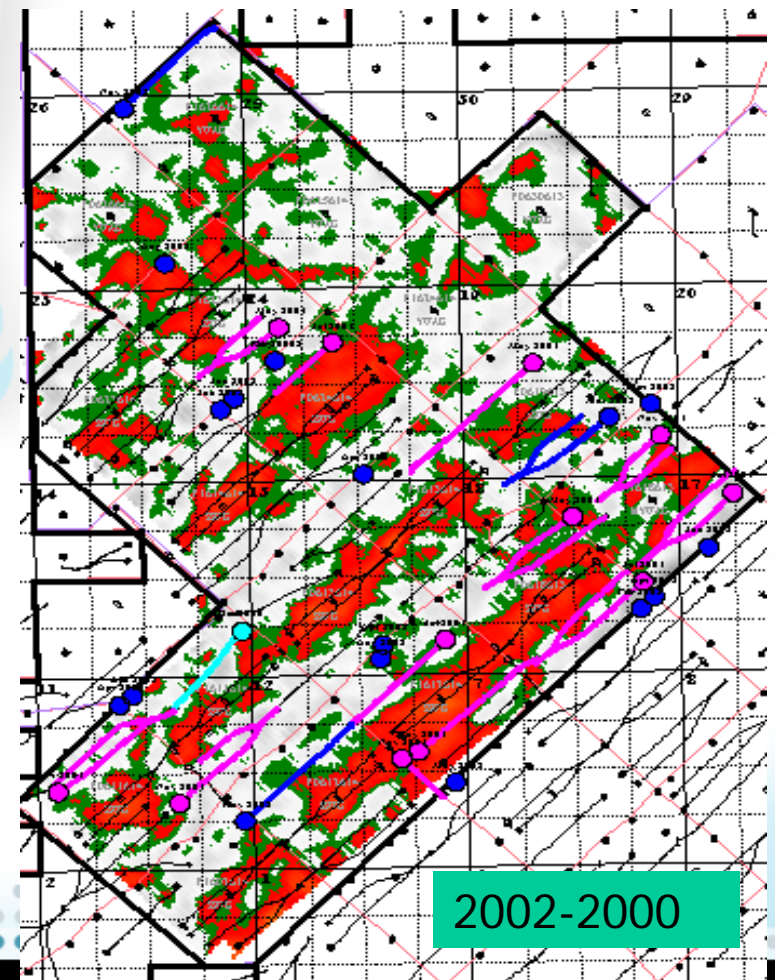
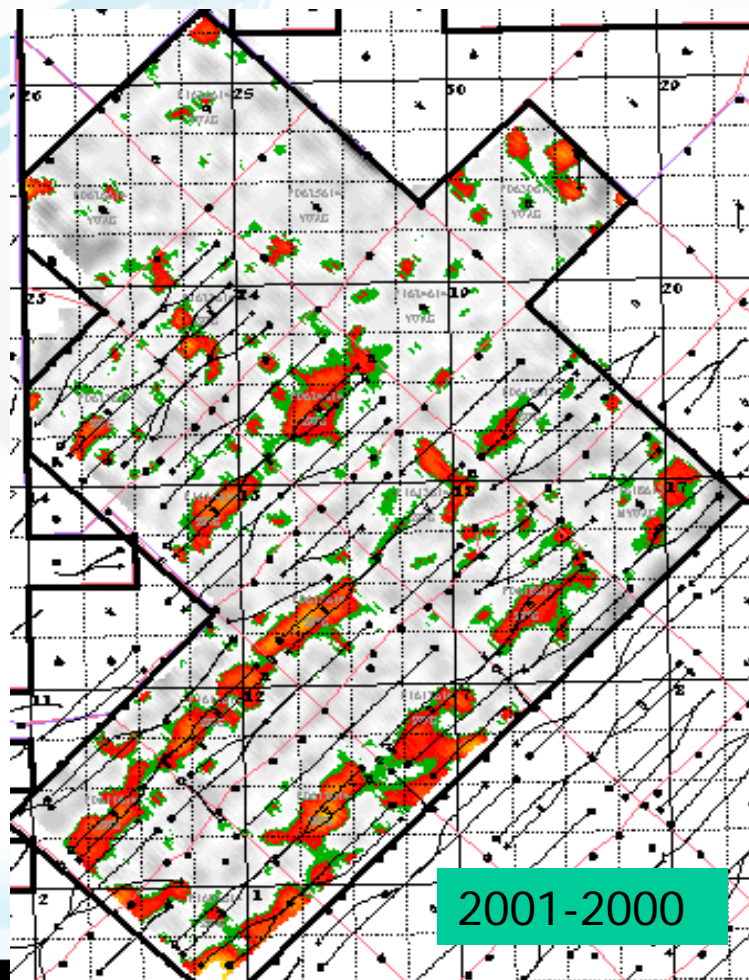
**Injected CO<sub>2</sub> dissolution (decreasing  $\delta^{13}C$  in produced fluid)**

**Injected CO<sub>2</sub>:  $\delta^{13}C = -34\%$**

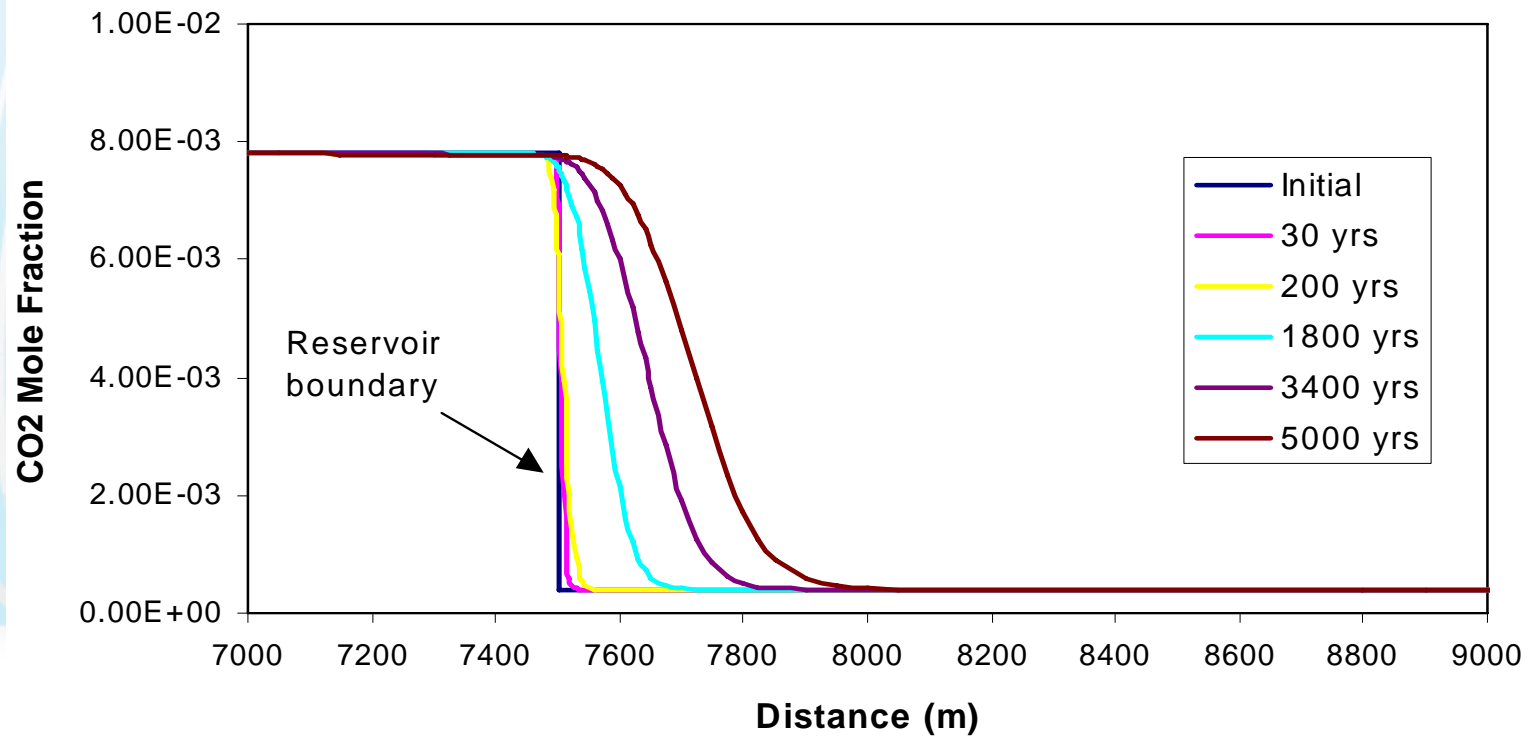


## 4D-3C Time-Lapse Seismic Surveys vs. Baseline survey (Sept. 2000)

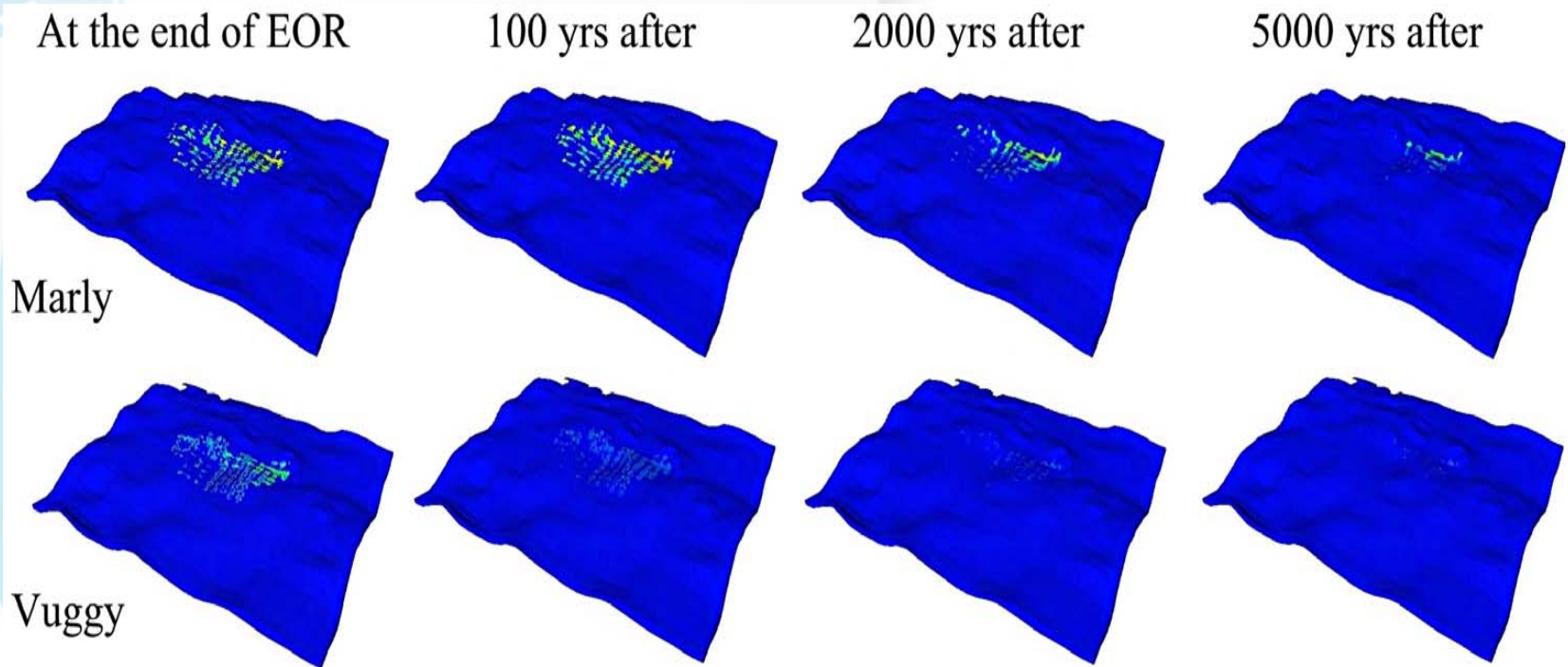
### Marly Zone



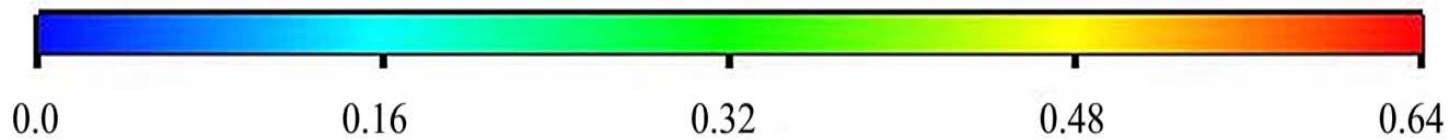
# CO<sub>2</sub> Movement in the Reservoir Plane



# Gas Saturation with Time

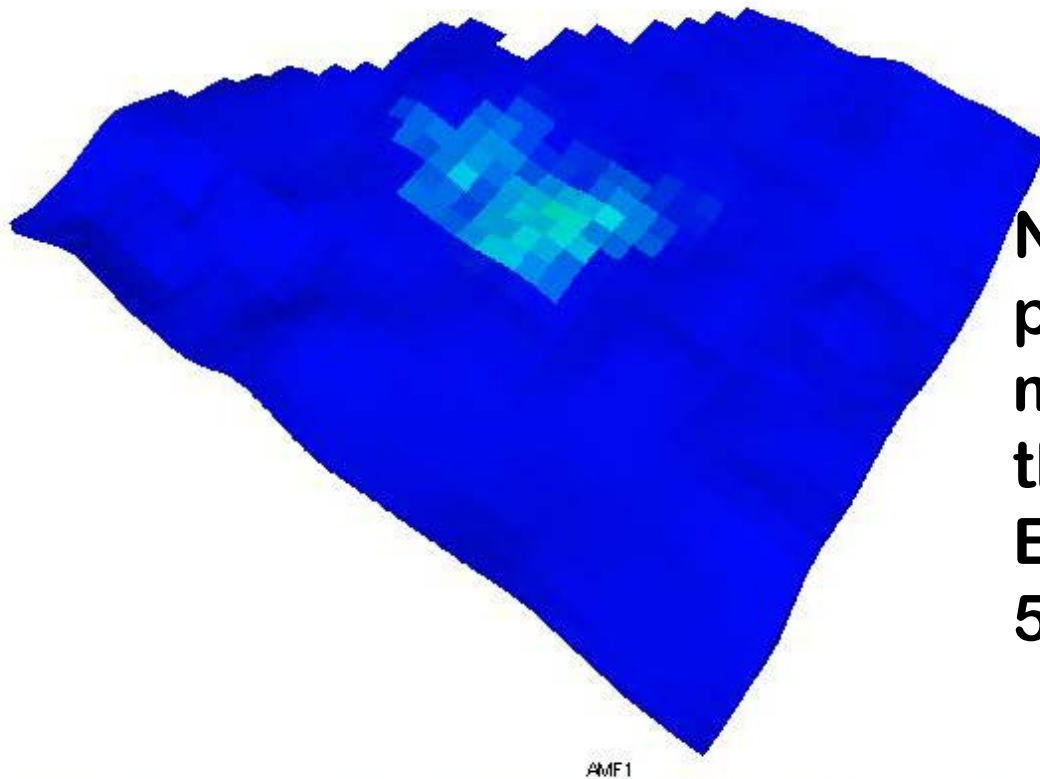


Gas Saturation

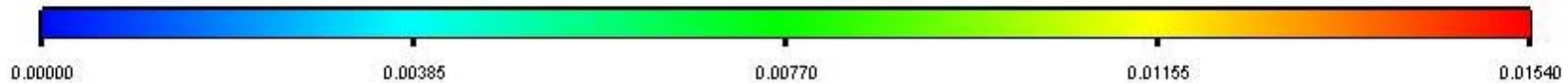


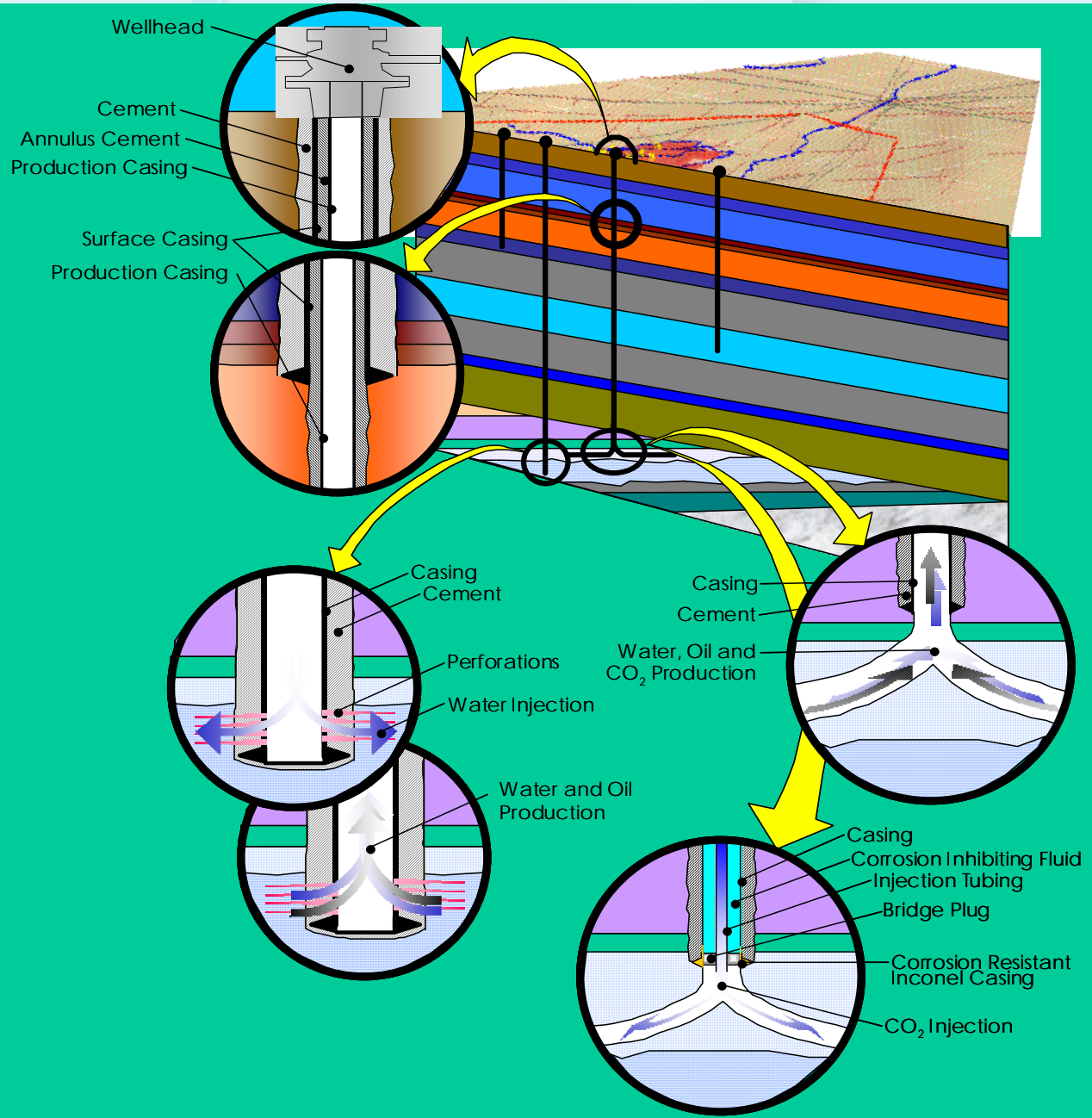
## Element of Risk: CO<sub>2</sub> Aqueous Concentration in Midale Evaporite

**5000 yrs**



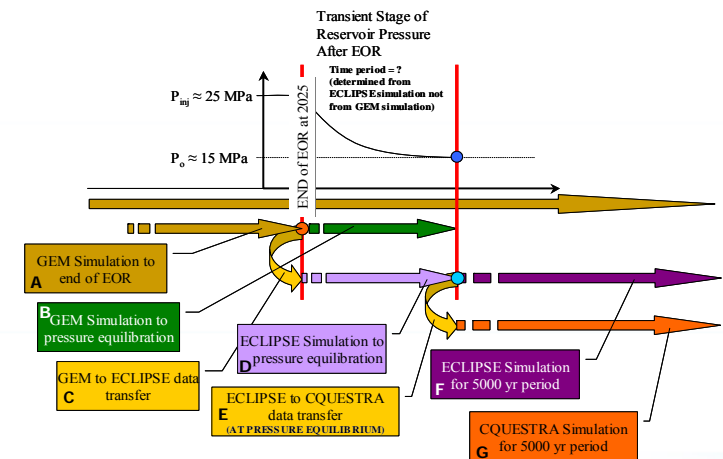
**No gas and oil phases migrate into the Midale Evaporite over 5000 yrs.**



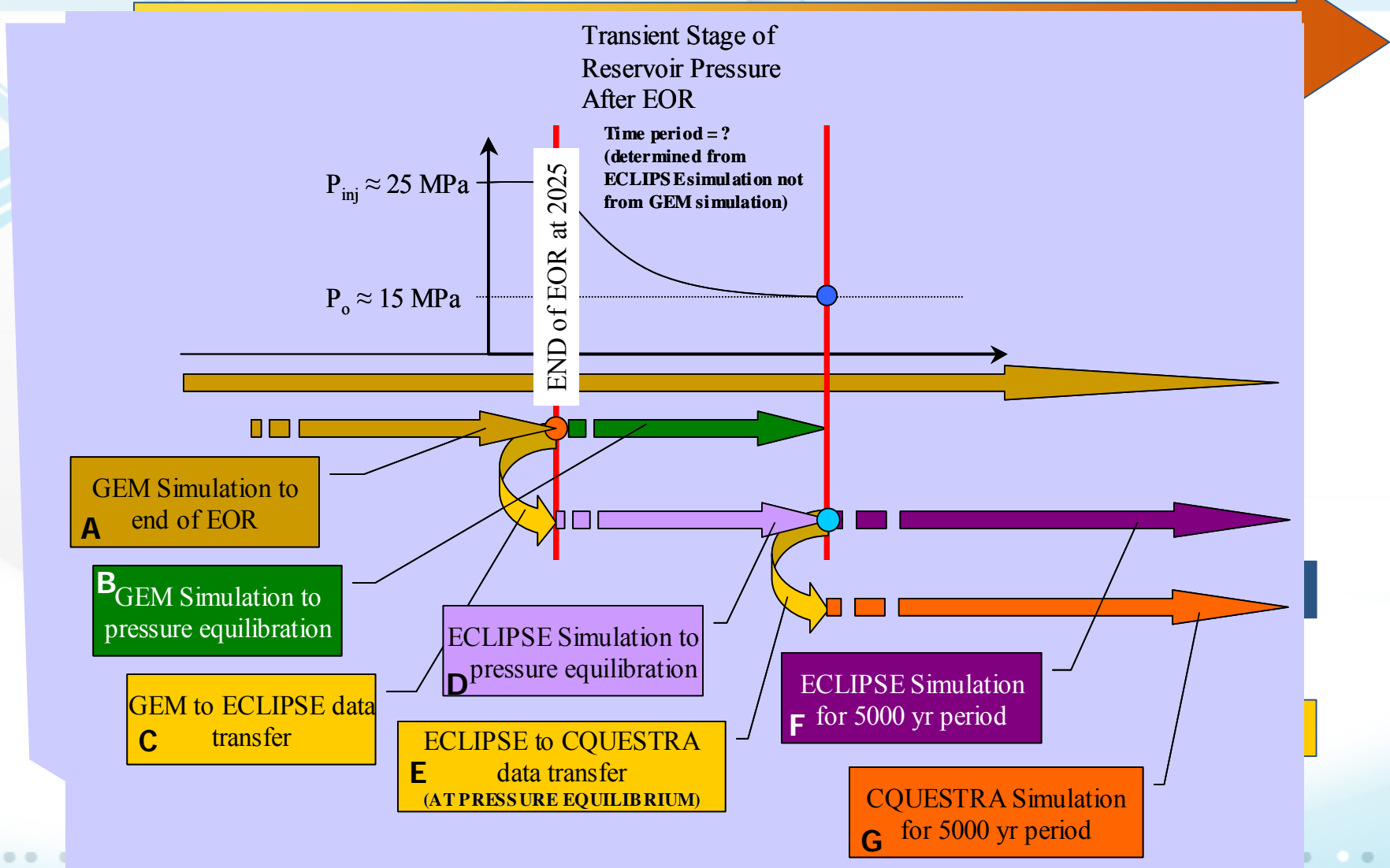


## Risk Assessment Methodology

- ❖ FEP's (Features, Events and Processes)
- ❖ Systems Analysis
- ❖ Scenario Development
  - Base Scenario
  - Alternative Scenario's
- ❖ Deterministic Risk Assessment
- ❖ Probabilistic Risk Assessment

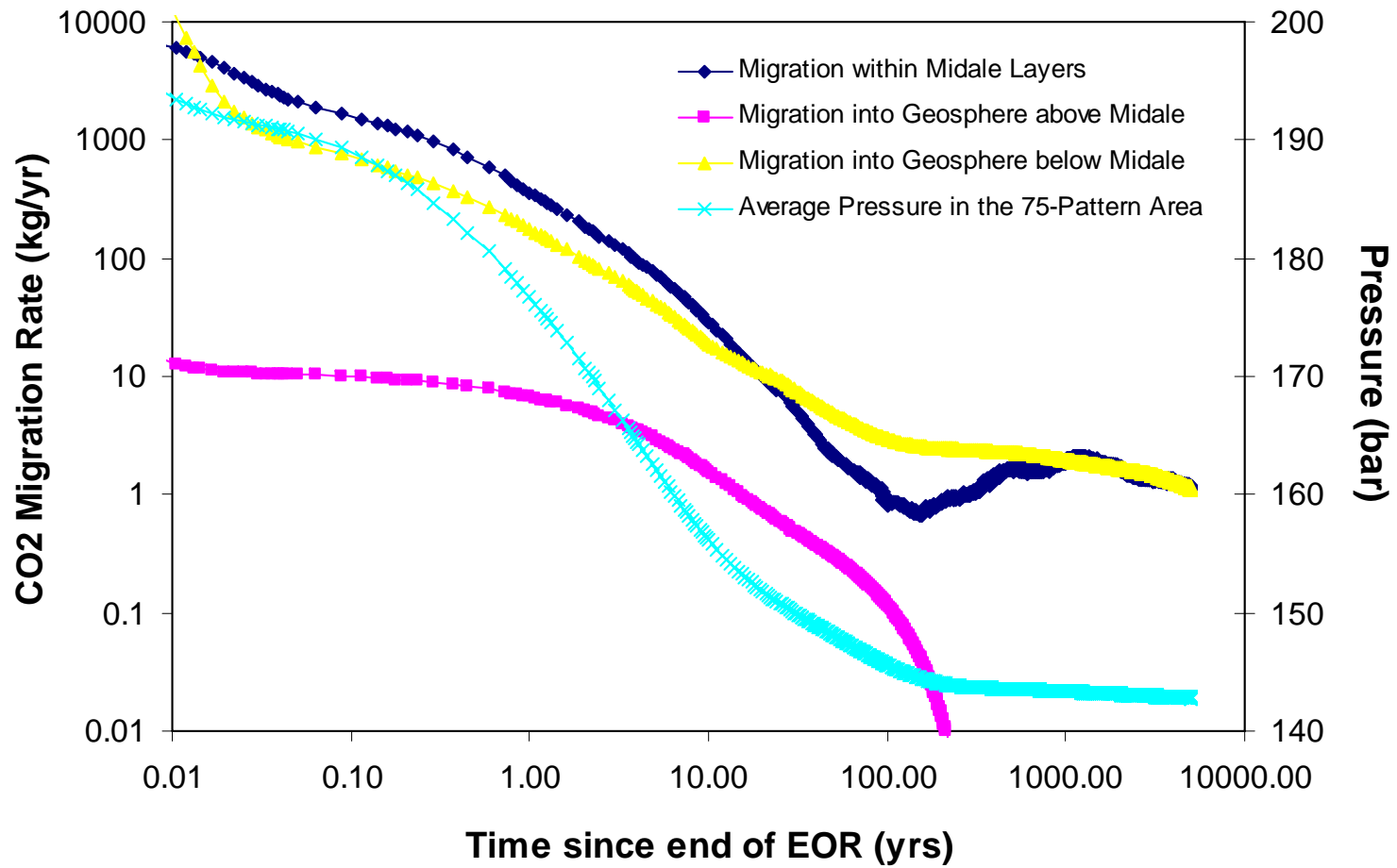


# Integration of Assessment Components





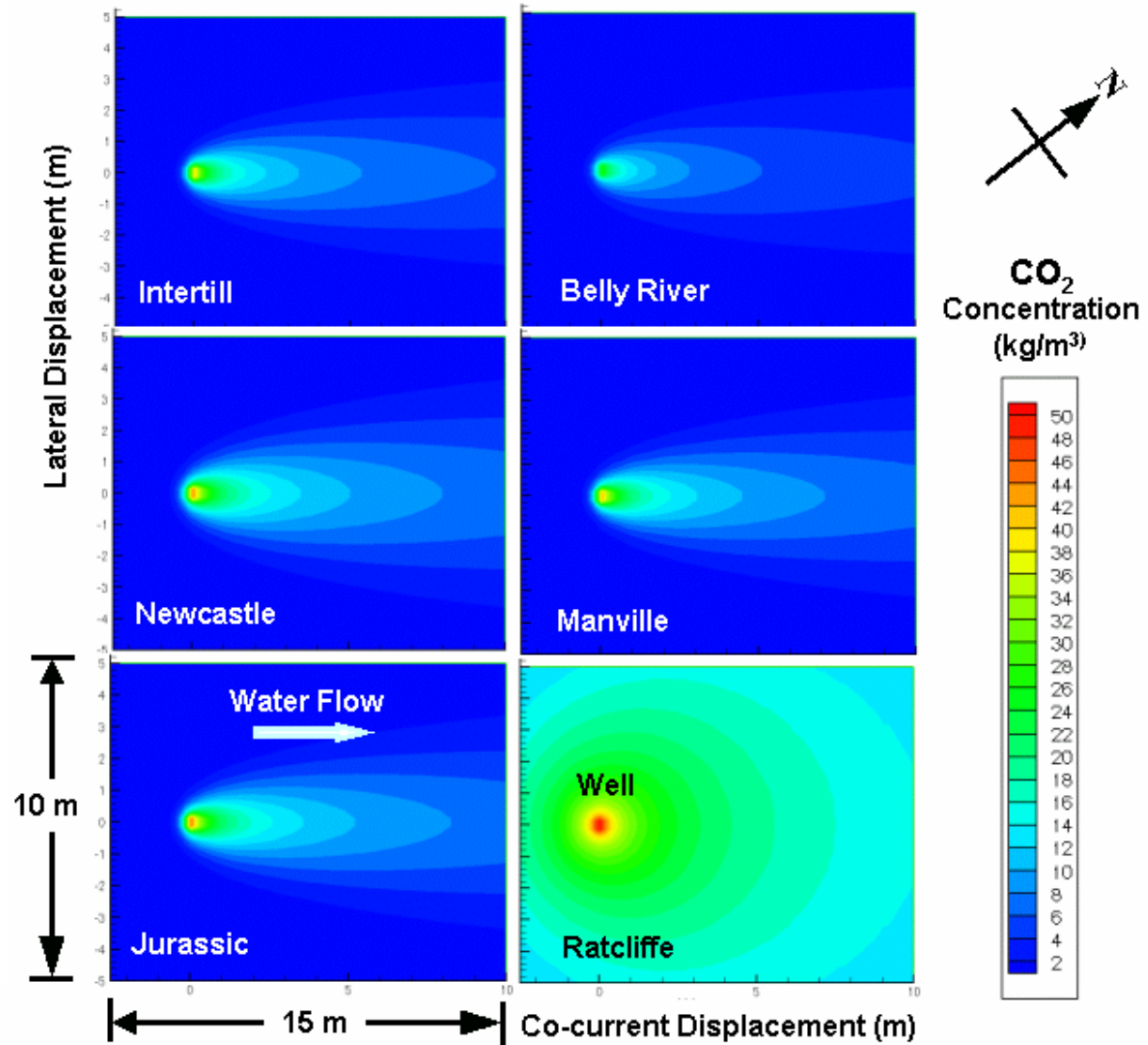
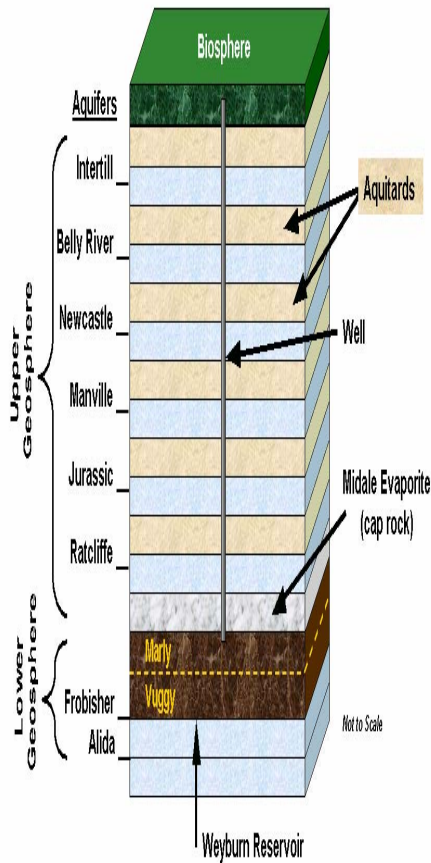
# CO<sub>2</sub> Migration Rate



# PRA Demonstration Case Study



Unlocking Tomorrow's Energy



# IEA GHG Weyburn CO<sub>2</sub> Monitoring and Storage Project

## Who's Involved?



Natural Resources  
Canada



*Pushing the  
boundaries*



Saskatchewan  
Industry and  
Resources



### ➤ 8 Industry Sponsors

- BP, Chevron, Dakota Gasification Co., Engineering Advancement Association of Japan, Nexen Canada, SaskPower, Total and TransAlta Utilities Corp.

### ➤ Numerous Research Organizations

- Canada, U.S. and Europe