Overview of the IEA GHG Weyburn-Midale CO_2 Monitoring and Storage Project

3rd CSLF Workshop on Capacity Building for Carbon Capture and Storage (CCS)

Al-Khobar, Saudi Arabia
26-30 January 2008

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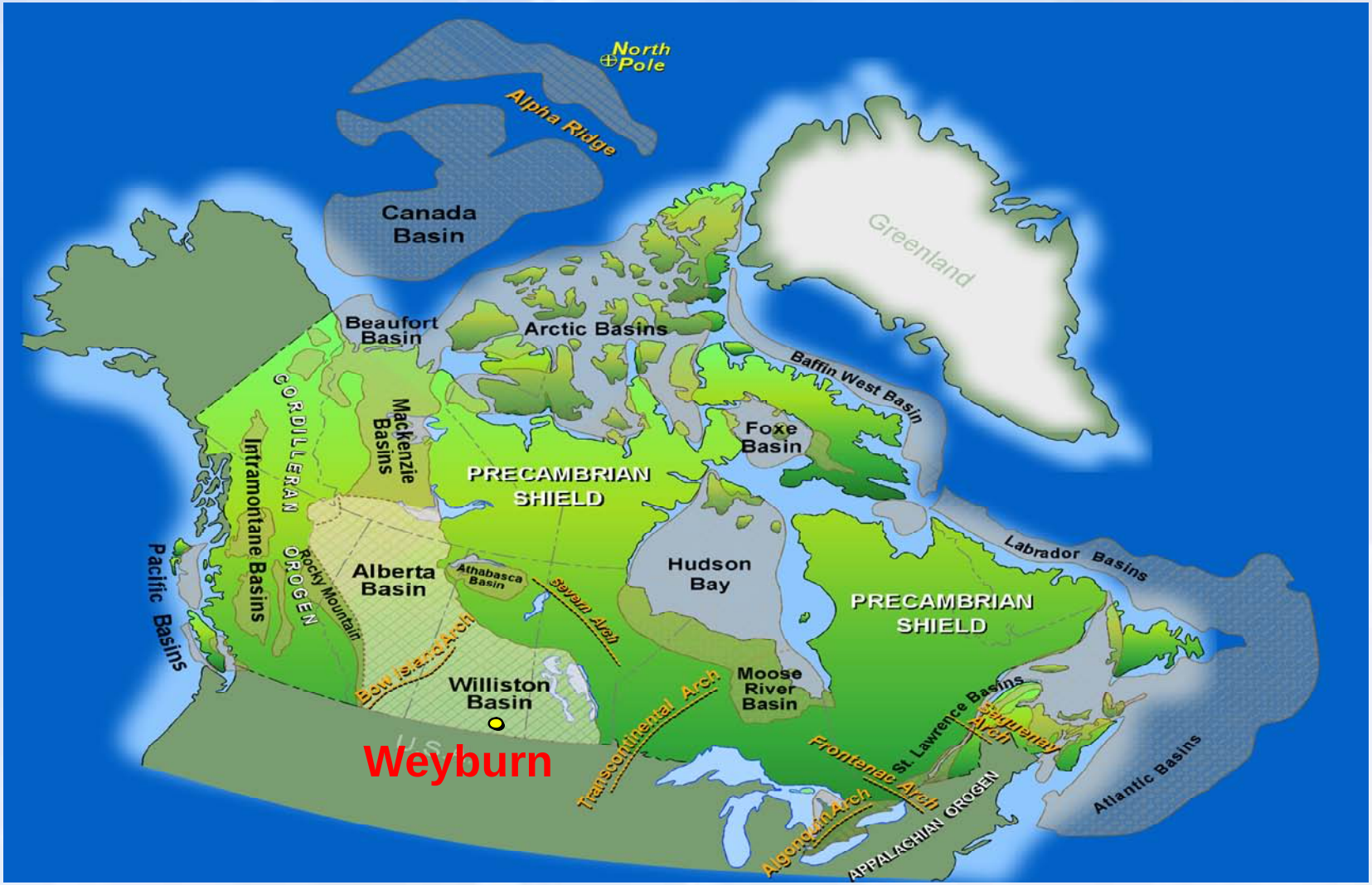
IEA GHG
WEYBURN-MIDALE
CO_2 MONITORING
AND STORAGE PROJECT

Outline of this presentation

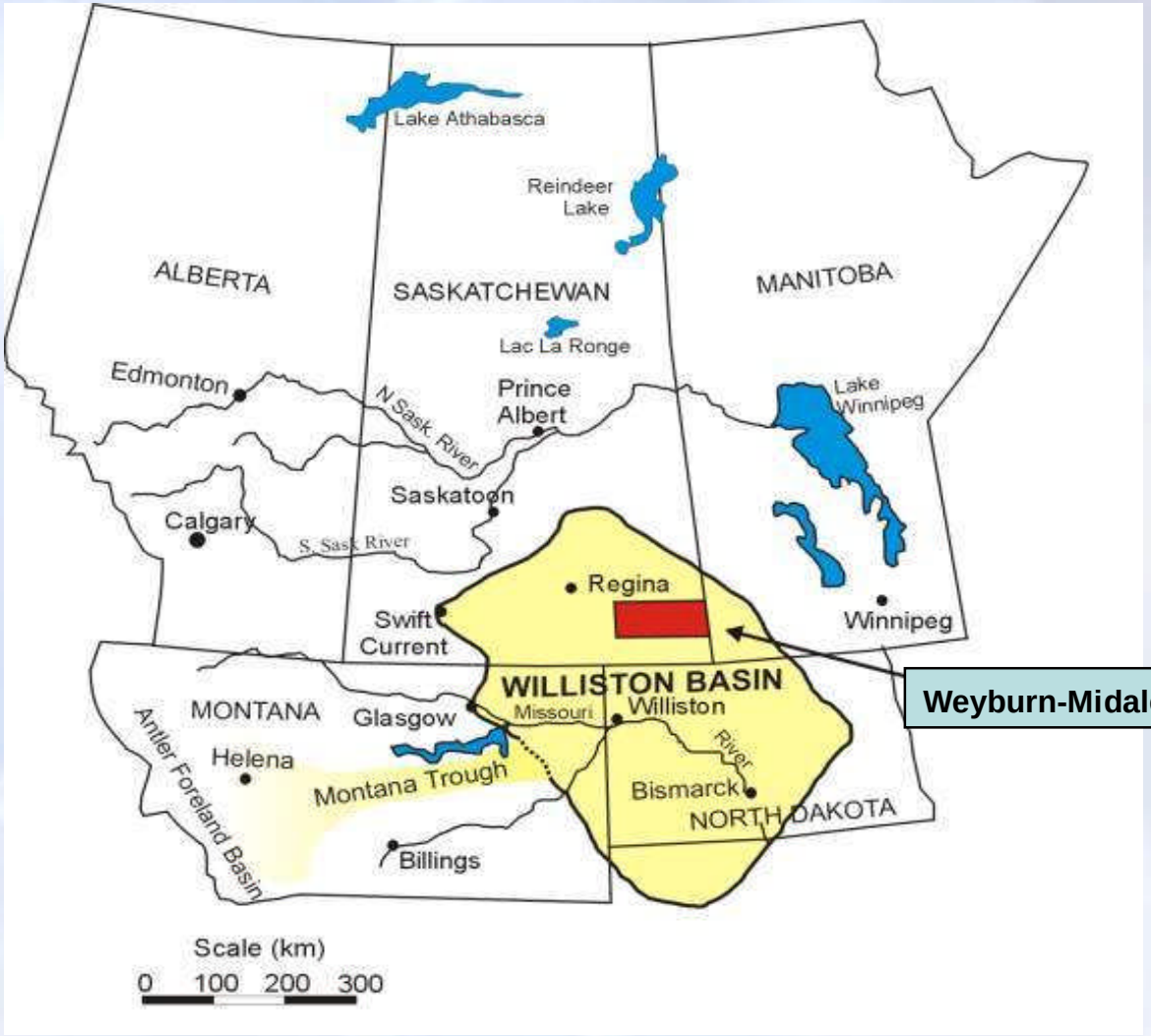
- Encana Weyburn and Apache Midale Commercial EOR Operations
- IEA GHG Weyburn CO_2 Monitoring and Storage Project: Overview and Results of Phase I (2000-2004)
- IEA GHG Weyburn-Midale CO_2 Monitoring and Storage Project : Final Phase (2007-2010)

Encana Weyburn and Apache Midale Commercial EOR Operations

Location of the Weyburn-Midale CO_2 Project



Location of the Weyburn-Midale CO_2 Project



Weyburn and Midale Oilfield Characteristics

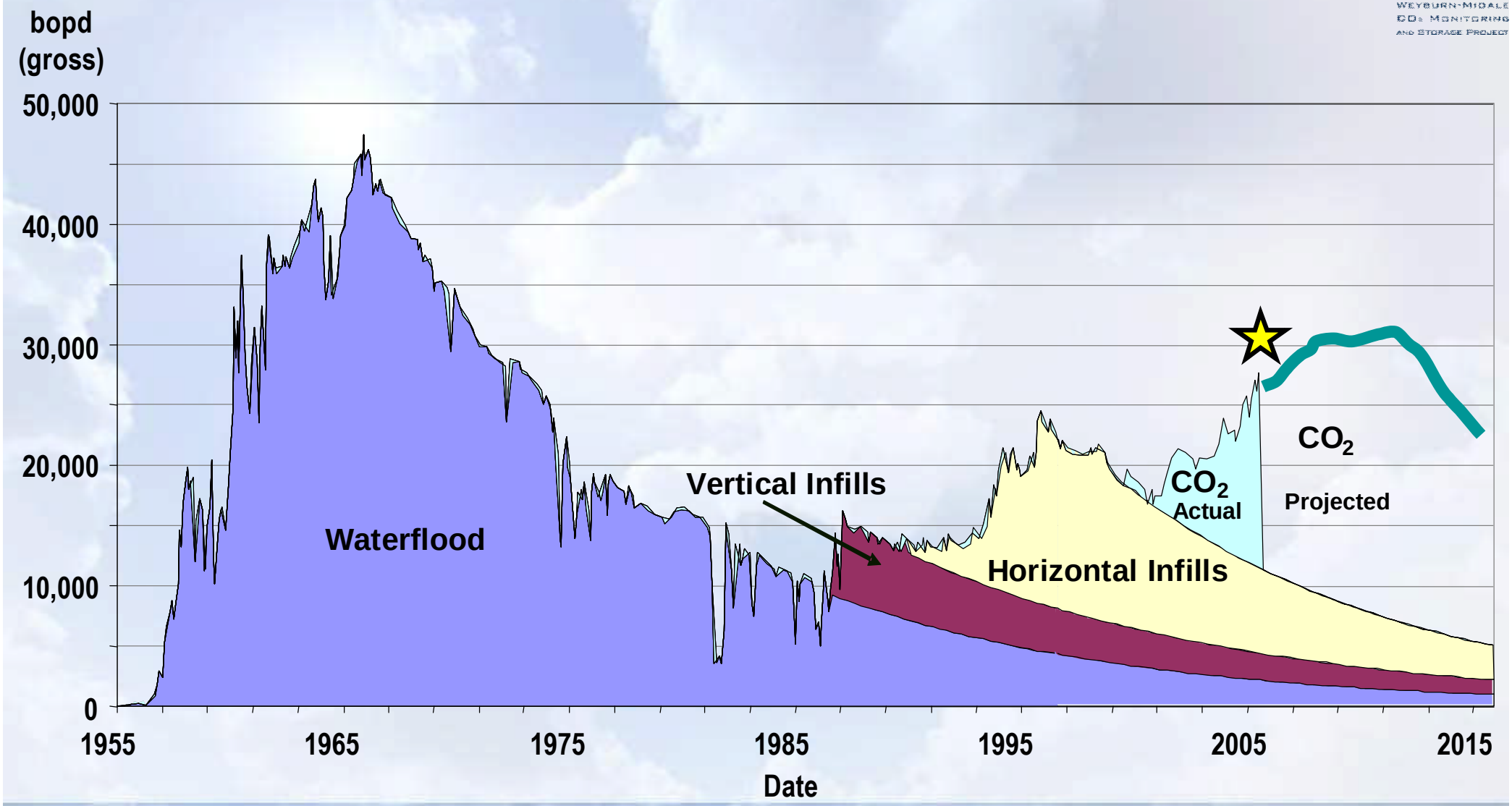
	Weyburn (*EnCana*)	Midale (*Apache*)
Field Size	180 km^2	104 km^2
Depth	1500 m	1500 m
Gross Pay / Net Pay	25 / 7.8 m	22 / 7.5 m
Zone Porosity	Marley Dolomite zone: 26% ; Vuggy Limestone zone:15%	
Average Porosity	17.2%	16.3%
Zone Permeability	Marley Dolomite zone: 10 mD ; Vuggy Limestone zone: 30 mD	
Average Water Saturation	31.7%	16.3%
Average Oil gravity	29.3 API (880 kg/m^3)	29.8 API (877 kg/m^3)
Minimum miscibility pressure	14 -16 MPa (2030 - 2320 psi)	
Original oil in place	1.4 billion bbl	515 million bbl
Oil recovery pre-EOR (primary, waterflood, infill)	370 millions bbl (26.4% OOIP)	154 million bbl (25.4% OOIP)
Number of injector wells	n/a	60 – 70, incl. 10 CO_2
Number of producing wells	360 (in EOR area)	270 (total field)

Weyburn and Midale Operating Statistics

	Weyburn (*EnCana*)	Midale (*Apache*)
Start of CO_2 injection / duration	2000 / 30 years	2005 /30 years
Injection pressure	10 - 11 MPa (1450 - 1600 psi)	
Injection of source CO_2 Recycle of CO_2 & produced gas	6,500 t/d (125 MMscf/d) 60 MMscf/d	1,300 t/d (25 MMscf/d) 6 – 8 MMscf/d
Annual amount of source CO_2 injected	2.4 million tonnes	474,000 tonnes
Total amount source CO_2 injected to date	9.5 million tonnes (Feb 2007)	n/a
Incremental oil production	18,000 b/d for EOR area 30,600 b/d for total unit	n/a
Projected total incremental oil recovery due to CO_2	155 million barrels	60 million barrels (17% OOIP)
CO_2 utilization factor	3 - 4 Mcf/b	2.3 Mcf/b
Projected amount of CO_2 stored at project completion	30+ million tonnes* (gross) 26+ million tonnes (net)	10+ million tonnes* (gross) 8.5+ million tonnes (net)
Total capital cost of EOR project	CAD$1 billion	CAD$95 million

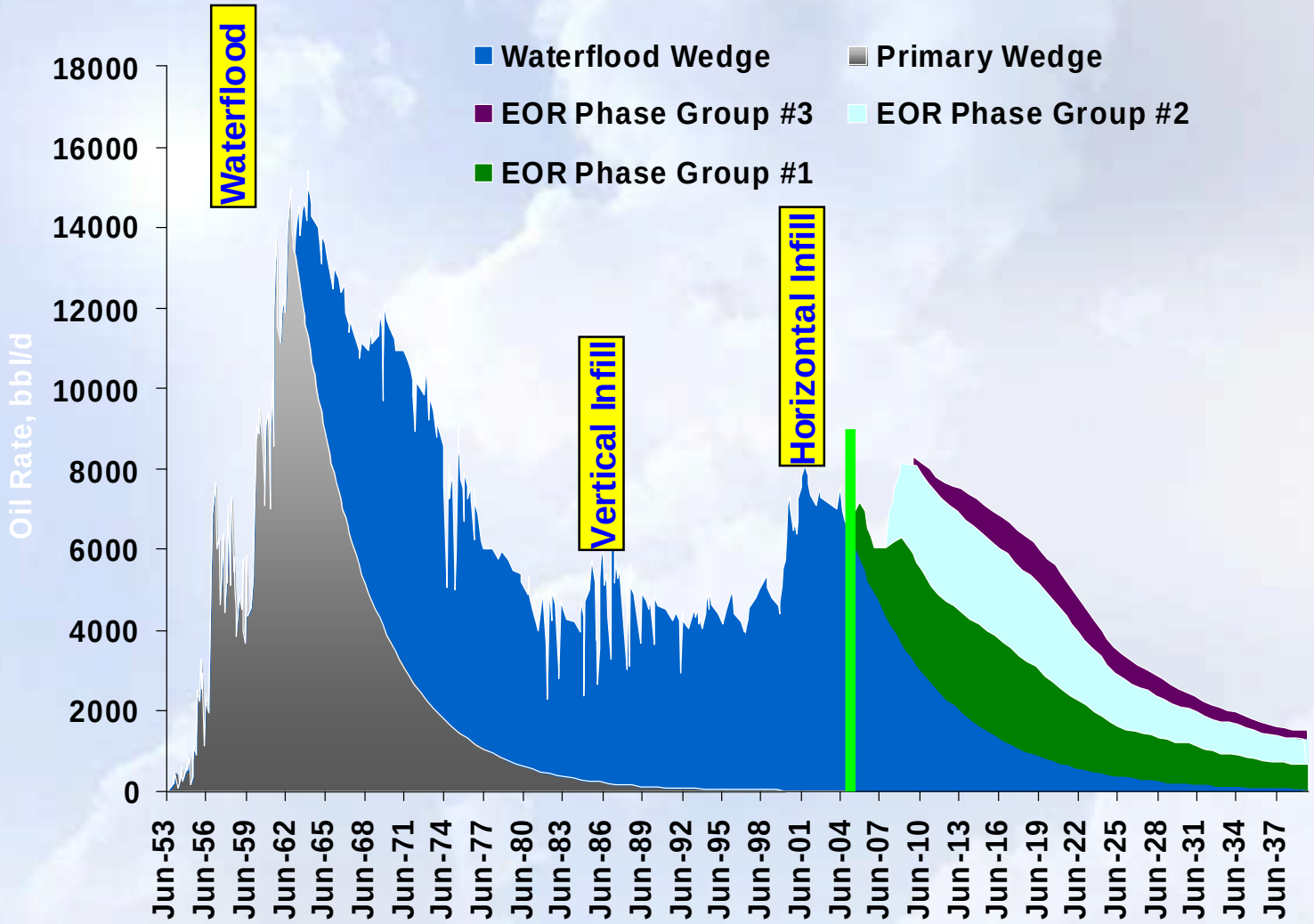
**** Equivalent to removing more than 8 million cars off the road for a year***

EnCana's Weyburn Unit Production Data



EnCana Corporation

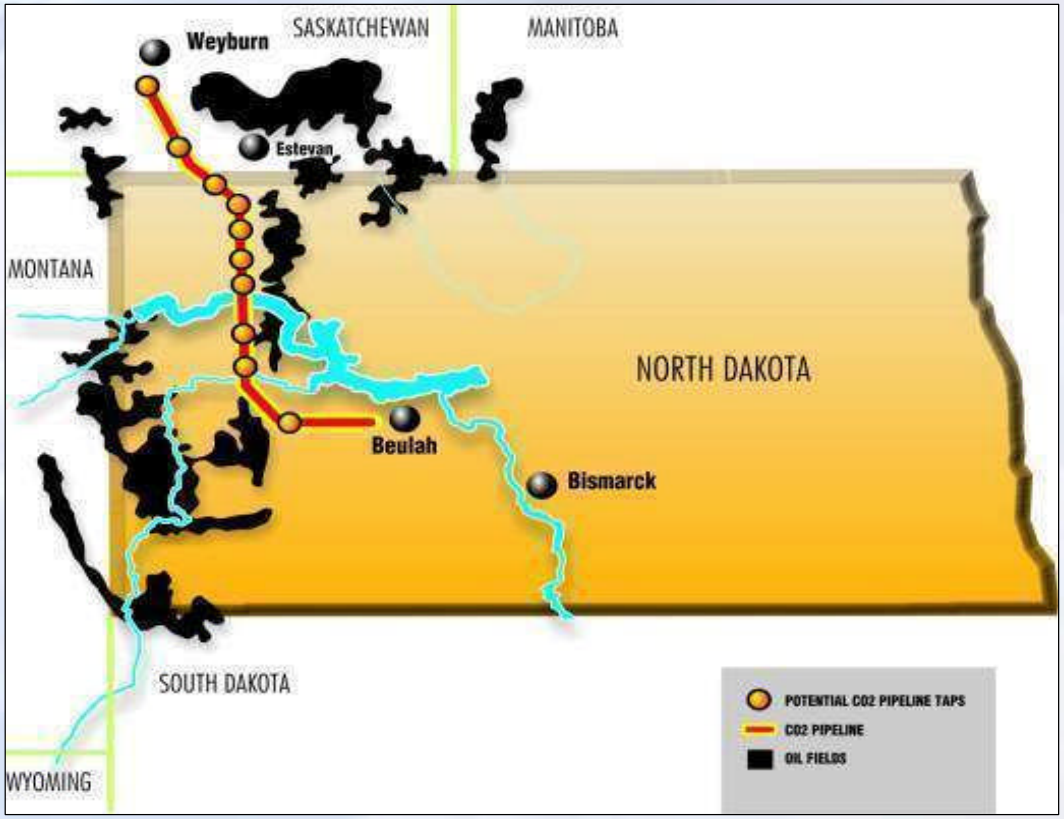
Apache's Midale Unit Production Data



Source of CO_2

Dakota Gasification Company, Beulah, North Dakota, U.S.A.:

- Produces 13,000 tonnes/d of CO_2 as by-product of lignite coal gasification, of which 8,000 t/d is available for EOR
- CO_2 purity is 95% (less than 2% H_2S); trace mercaptans
- 5000 t/d contracted and transported through 320-km pipeline to Weyburn oilfield
- Pressure is 1000 psi (68 atm/ 6.9 MP/68.9 bar)



IEA GHG Weyburn CO2 Monitoring and Storage Project: Overview and Results of Phase I (2000-2004)

Phase I: 2000-2004

Objectives

- *to **predict and verify** the ability of oil reservoirs to securely and economically contain CO_2 through a comprehensive analysis of various methodologies*
- *to **develop monitoring and modeling** methods to address the long-term migration and fate of CO_2*

To address these objectives, Phase I was organized along 4 main "themes", which comprised over 50 separate research subtasks:

1. Geological characterization of geosphere and biosphere
2. Prediction, monitoring and verification of CO_2 movements
3. CO_2 storage capacity and distribution predictions and the application of conformance control treatments
4. Long-term risk assessments of the storage site

Phase I Partners

Government Sponsors
$18 million

- Natural Resources Canada
- United States Dept. of Energy
- European Commission
- IEA GHG R&D Programme
- Saskatchewan Industry and Resources
- Alberta Energy Research Institute

Industry Sponsors
$22 million

- EnCana
- BP
- ChevronTexaco
- Dakota Gasification Co.
- RITE (Engineering Adv. Association of Japan)
- Nexen
- SaskPower
- Total
- TransAlta

Research Organizations
In kind contributions

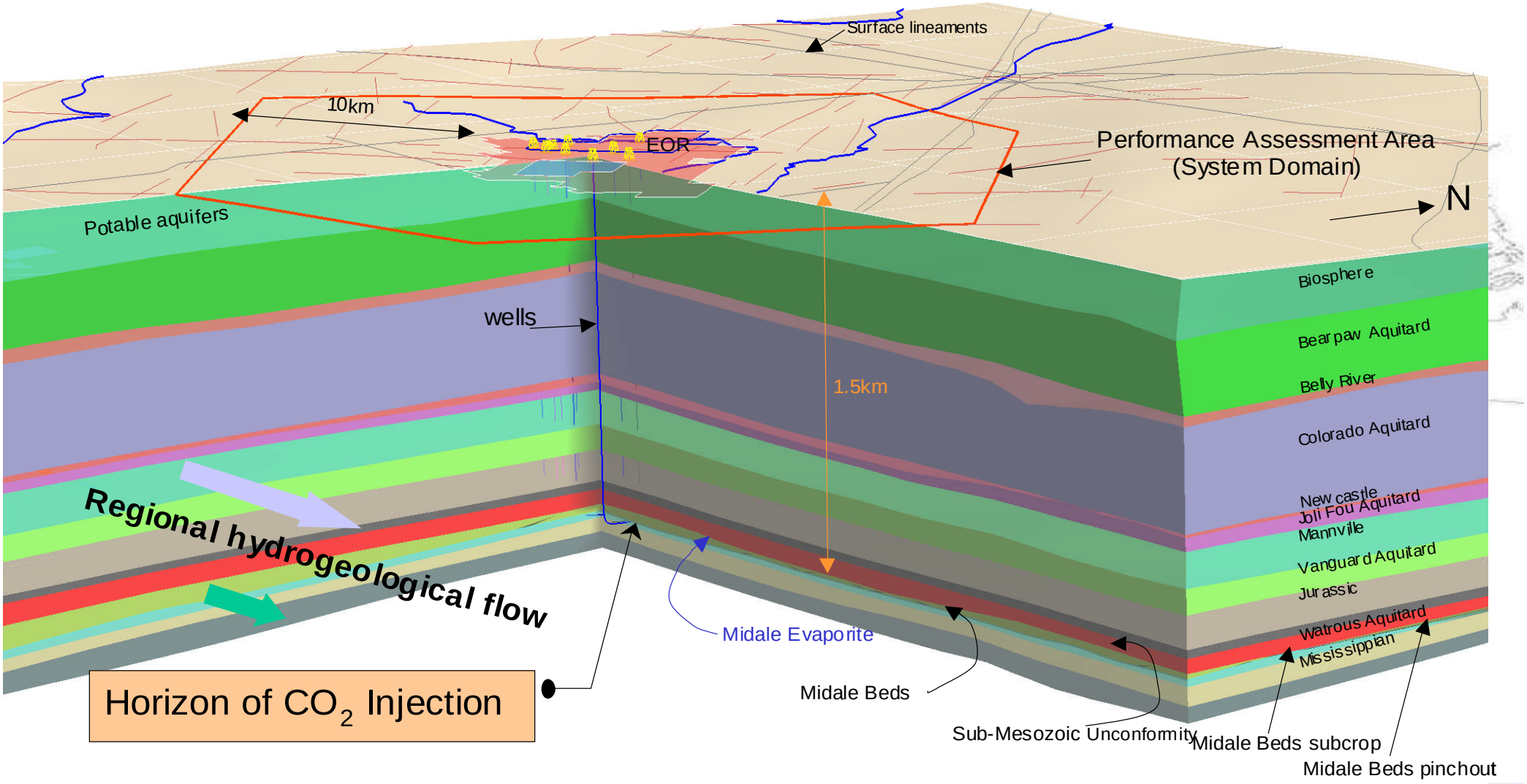
- Saskatchewan Research Council (SRC)
- Alberta Research Council (ARC)
- Canadian Energy Research Institute (CERI)
- ECOMatters (ECOM)
- GEDCO Inc. (GEDCO)
- Geological Survey of Canada (GSC)
- Hampson Russell (HR)
- J.D. Mollard and Associates Ltd. (JDMA)

- Rakhit Petroleum Consulting Ltd. (RPCL)
- University of Regina (U of R)
- University of Saskatchewan (U of S)
- University of Alberta (U of A)
- University of Calgary (U of C)

- Colorado School of Mines, Golden, CO (CSM)
- Lawrence Berkeley National Laboratories, Berkeley, CA (LBNL)
- Monitor Scientific Corporation International, Denver, CO (MSCI)
- North Dakota Geological Survey (NDGS)

- British Geological Survey, Britain Bureau de Recherches Geologiques et Minieres, France (BRGM)
- Geological Survey of Denmark and Greenland (GEUS)
- Istituto Nazionale di Geofisica e Vulcanologia Quintessa Ltd. (INGV)
- Quintessa

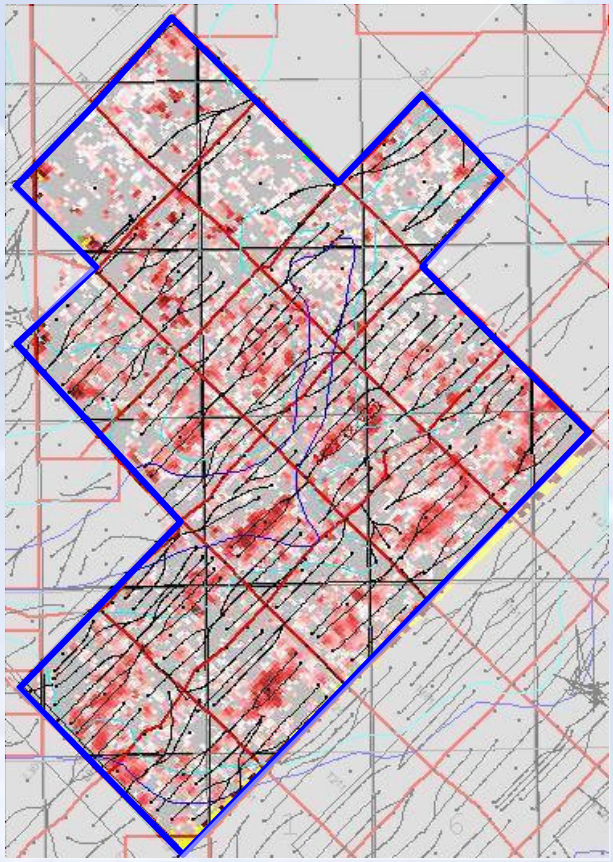
Project Location and Study Areas



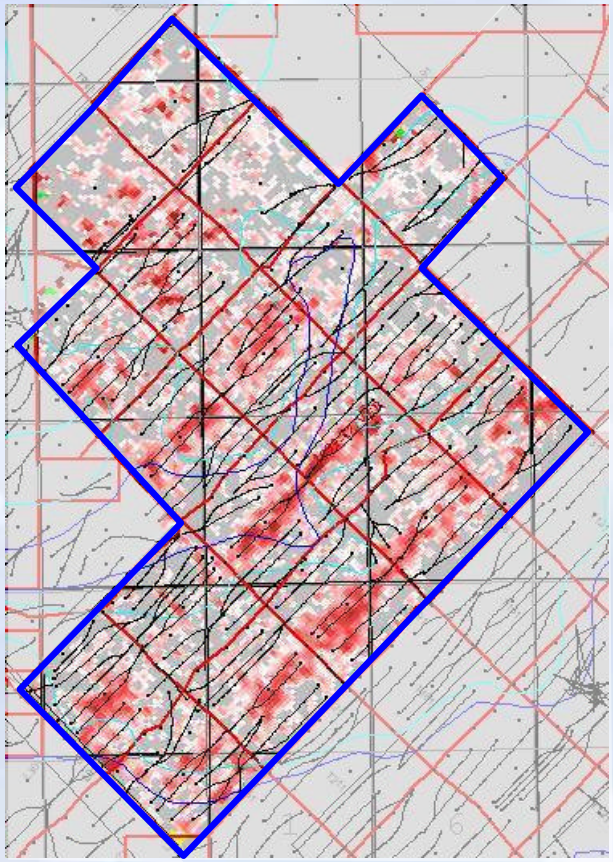
Source: Saskatchewan Geological Survey; University of Alberta

Tracking CO_2 Movement

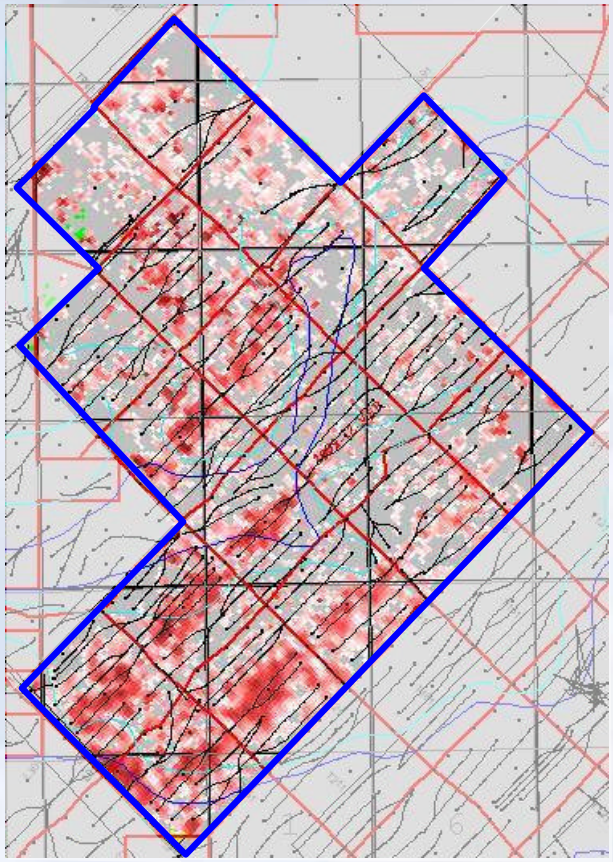
Seismic Surveys (Baseline to 2004) – Phase 1a



Baseline - 2001



Baseline - 2002



Baseline - 2004

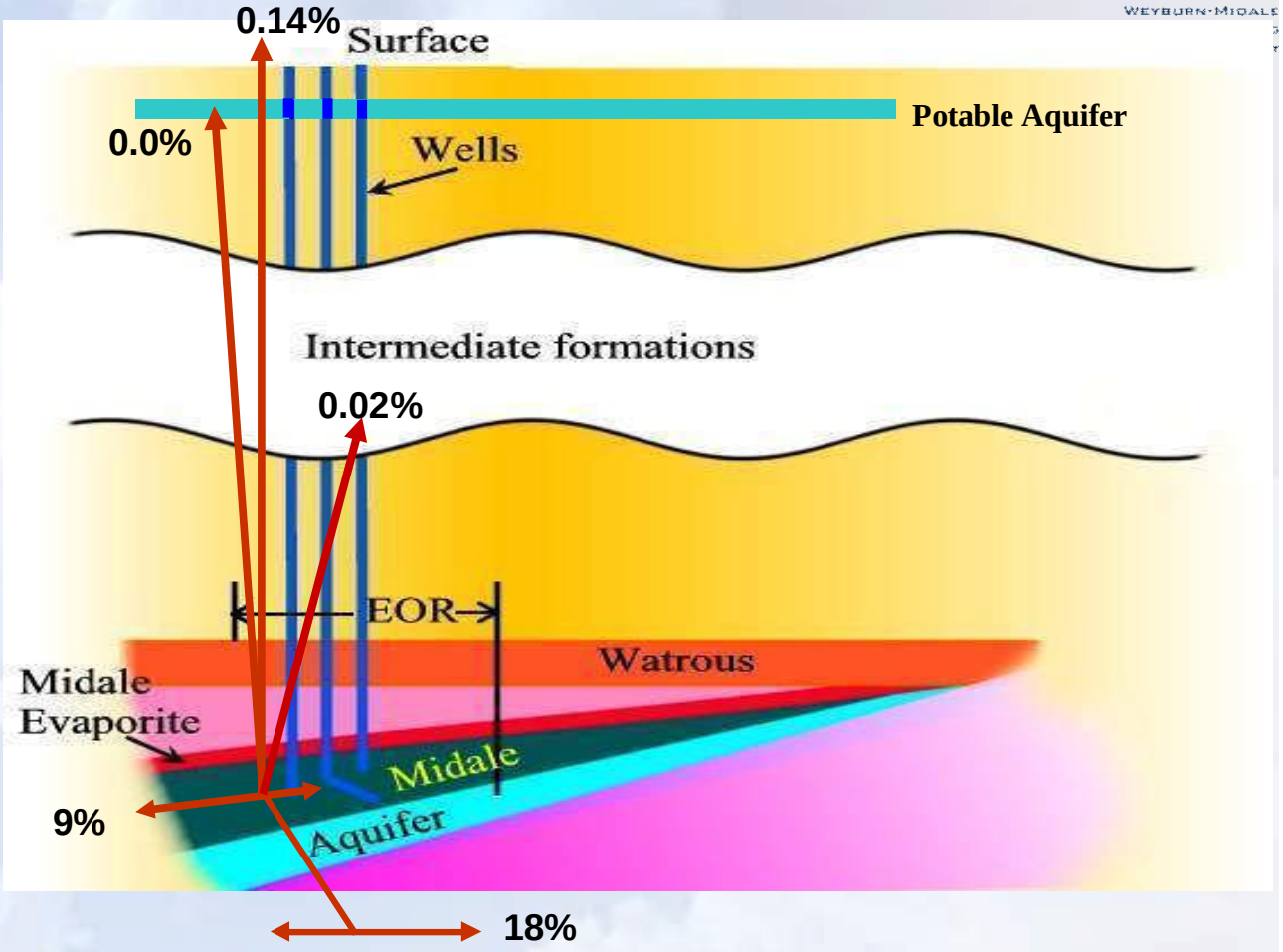
Phase I Results: Risk Assessment

Geological "container" at Weyburn is very effective:

- Primary carbonate and secondary shale seals are highly competent
- There is hydraulic separation and no fluid flow between adjacent aquifers

Initial simulation results indicate that after 5000 years over 98% of the initial CO_2 in place will remain stored:

- More sophisticated simulation work is required
- Risk management practices need to be developed



After 5000 years, 27% of CO_2 moved outside EOR area, but remained within study area

IEA GHG Weyburn-Midale CO_2 Monitoring and Storage Project

The Final Phase

Why pursue a Final Phase project?

Issues to be Addressed

Technical

- Unfinished work ("gaps") from Phase I
- Gaps identified by IPPC (Special Report on CCS, 2005)

Non-Technical / Policy

Favourable regulatory regime

- Site selection
- Operations
- Abandonment / post-abandonment
- Orphaned sites

Public understanding and acceptance

Facilitating fiscal policy regime

- Value placed on stored CO_2
- Credit trading mechanisms
- Financial / fiscal incentives

Outcomes Sought

- Technical knowledge transferred to enable widespread deployment
- Solid technical basis established for policy development

- Storage security
- Risk management
- Long-term liability
- Verifiable GHG reductions
- Public health and safety

- License to operate

- Sources-to-sinks infrastructure
- Widespread use
- Deep GHG cuts

Final Phase Objectives

Best Practices Manual

- Will guide all aspects of future CO_2 EOR storage projects

[Integration]

Technical Components
(90% of budget)

1. Site Characterization / Selection
2. Wellbore Integrity
3. Monitoring and Verification
4. Risk Assessment

Non-Tech Components
(10% of budget)

1. Regulatory Issues
2. Public Communication and Outreach
3. Business Environment / Fiscal Policy

Final Phase: Partners to Date

Government Sponsors

- Natural Resources Canada
- United States Dept. of Energy
- IEA GHG R&D Programme
- Saskatchewan Industry and Resources
- Alberta Energy Research Institute
- RITE (Research Institute of Innovative Technology for the Earth)

ptrc
Petroleum Technology Research Centre

Industry Sponsors

- Apache
- EnCana
- Chevron
- OMV Austria
- Aramco Services Co
- SaskPower.
- Schlumberger
- Shell

Research Organizations

- Alberta Research Council (ARC)
- Canadian Light Source – Synchrotron
- ECOMatters (ECOM)
- Geological Survey of Canada (GSC)
- Permedia Group
- Saskatchewan Research Council (SRC)

- T.L. Watson & Associates
- University of Regina (U of R)
- University of Sask. (U of S)
- University of Alberta (U of A)
- University of Calgary (U of C)
- URS Canada Inc.

- Fugro Seismic Imaging
- Lawrence Livermore National Laboratories

- University of Bristol UK
- International Energy Agency

Final Phase – Technical Program

Theme 1 – Geological Integrity (Site Selection)

- develop firm protocols for site selection
- identify minimum data set required for successful site selection using full-cycle risk assessment
- integrate hydrogeological, geophysical, geological data sets to create complete picture of seal integrity
- further study leakage and storage integrity in natural analogues
- summarize impact of CO_2 on geochemical and geomechanical processes and regional reservoirs and seals

Theme 2 – Wellbore Integrity

- complete identifying essential parameters for well-bore integrity
- compile list of well remediation technologies that can be applied
- describe current well abandonment trends and how they may impact future abandonment requirements
- conduct cased-hole dynamic testing (look for pressures and mobile fluids that signal CO_2 migration out of the zone)
- document safe practices and effect on wellbore integrity and geomechanics

Final Phase – Technical Program

Theme 3 – Storage Monitoring Methods

- Characterize the accuracy of monitoring technologies for quantitative prediction of CO_2 location and volume
- determine if multi-year 4D seismic programs are an appropriate monitoring and verification requirement?
- determine CO_2 distribution through in-situ time-lapse well logging; spinner surveys; selective drilling, coring and logging of slim holes
- continue to explore passive seismic monitoring

Theme 4 – Risk Assessment and Storage Mechanisms

- complete full-field risk assessment from Phase 1
- determine risk levels for various storage optimization scenarios
- describe ultimate fate of CO_2, the relative volumes in each storage/ trapping mechanism, the time needed for trapping, and factors affecting these mechanisms
- Study ways for stimulating and accelerating CO_2 mineral fixation at reservoir conditions

Final Phase – Non-Technical Program

Public Communications and Outreach

- With stakeholders, develop a Communication Strategy based on the Weyburn-Midale experience and other major international CO_2 geological storage projects:
  - Identify and focus on issues of key interest to policy makers, regulators, investors and the local and national public
  - Communicate in the most appropriate manner the technical information from the Best Practices Manual and other relevant sources to these essentially non-technical audiences
  - Develop and/or participate in development of CCS educational materials
  - Launch the public communication process early
- Based on issues and feedback from stakeholders, revisit and revise the Best Practices Manual accordingly

Overall Status of the Final Phase

- Continued financial support by governments for the Final Phase is confirmed: NRCan, US DOE/NETL, Japan, Saskatchewan and Alberta
- Sponsorship from industry is enhanced to include new participants from different sectors
- Total funding (cash and in-kind) is expected to be in the order of $40 million, similar to that in Phase I
- Agreements with sponsors and research performers have been finalized or are currently being executed
- Budget envelopes (2007-2010) have been approved (90% technical; 10% policy)

Conclusions

- Based on preliminary Phase I results, the geological setting at Weyburn-Midale appears to be highly suitable for long-term CO_2 geological storage
- Project has arguably developed the most complete, comprehensive, peer-reviewed data set in the world for CO_2 geological storage
- An international team of high-quality researchers has been established and strong international leadership has been demonstrated by Canada, the USA and the EU through continued financial and managerial support
- International credibility and recognition by the IEA GHG R&D Programme and the Carbon Sequestration Leadership Forum (CSLF) have been achieved
- The final product – the Best Practices Manual - will serve as practical technical guide for the design and implementation of EOR-type CO_2 storage, while accelerating the development of: (i) appropriate regulations for CO_2 storage; (ii) effective public consultation process; and (iii) public policy that provides effective incentives to ensure widespread deployment of long-term CCS

Thank you for your attention!

Any Questions?

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How does CO_2 Enhanced Oil Recovery (EOR) work?