Carbon Capture and Storage: the QUEST Project*

Luc Rock[1] and Simon O'Brien[1]

Search and Discovery Article #80577 (2017)**
Posted February 13, 2017

*Adapted from oral presentation given at AAPG 2016 Annual Convention and Exhibition, Calgary, Alberta, Canada, June 19-22, 2016

[1]Shell Canada Limited, Calgary, Alberta, Canada (Luc.Rock@shell.com)

Abstract

Carbon capture and storage (CCS) has been identified by the Intergovernmental Panel on Climate Change (IPCC) and the International Energy Agency (IEA) as a technology that will play a crucial role in reducing CO_2 emissions to the atmosphere. In Canada, Shell, on behalf of the Athabasca Oil Sands Project venture (Shell Canada Energy, Chevron Canada Limited, Marathon Oil Canada Corporation), announced in September 2012 that it was proceeding to construct the Quest Carbon Capture and Storage project. QUEST will capture more than one million tonnes of CO_2 per year from the Scotford oil sands bitumen Upgrader located near Edmonton, Alberta, reducing the direct CO_2 emissions from the Upgrader by up to 35%. The captured CO_2 will be injected into the Basal Cambrian Sandstone, a deep saline aquifer located at a depth of about 2 km below ground surface, over a potential time period of 25 years. Quest is the first large-scale commercial application of carbon capture and storage technology at an oil sands operation. An important part of the QUEST project is its Measurement, Monitoring and Verification (MMV) plan to demonstrate containment and conformance of the injected CO_2. The aim of this presentation is to provide an overview of the QUEST project with a focus on Site Selection and characterization and Measurement Monitoring and Verification plan to address containment and conformance of the injected CO_2.

References Cited

Bachu, S., M. Brulotte, M. Brobe, and S. Stewart, 2000, Suitability of the Alberta subsurface for carbon-dioxide sequestration in geological media: Earth Sciences Report, Alberta Research Council, Edmonton, AB, Canada, 86 p.

Meijer Drees, N.C., 1994, Devonian Elk Point Group of the Western Canada Sedimentary Basin: in Geological Atlas of the Western Canada Sedimentary Basin, G.D. Mossop and I. Shetsen (comp.), Canadian Society of Petroleum Geologists and Alberta Research Council, Accessed December, 2012, http://www.ags.gov.ab.ca/publications/wcsb_atlas/atlas.html

CARBON CAPTURE AND STORAGE: THE QUEST PROJECT

AAPG

Annual Convention & Exhibition

June 2016

Luc Rock & Simon O'Brien

CCS – CARBON CAPTURE & STORAGE

Large Scale Projects around the world (dedicated geological storage)

(source: Global CCS Institute, https://www.globalccsinstitute.com/projects/large-scale-ccs-projects)

QUEST - LOCATION

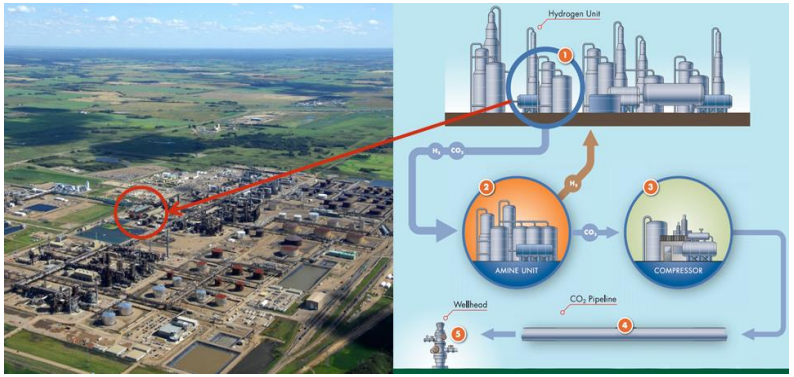
- Capture plant located in Fort Saskatchewan, approx 50 km N.E. of Edmonton

AGENDA

1. Quest overview
2. Site selection & characterization
3. Measurement, Monitoring and Verification (MMV) plan
4. Current Status

OVERVIEW

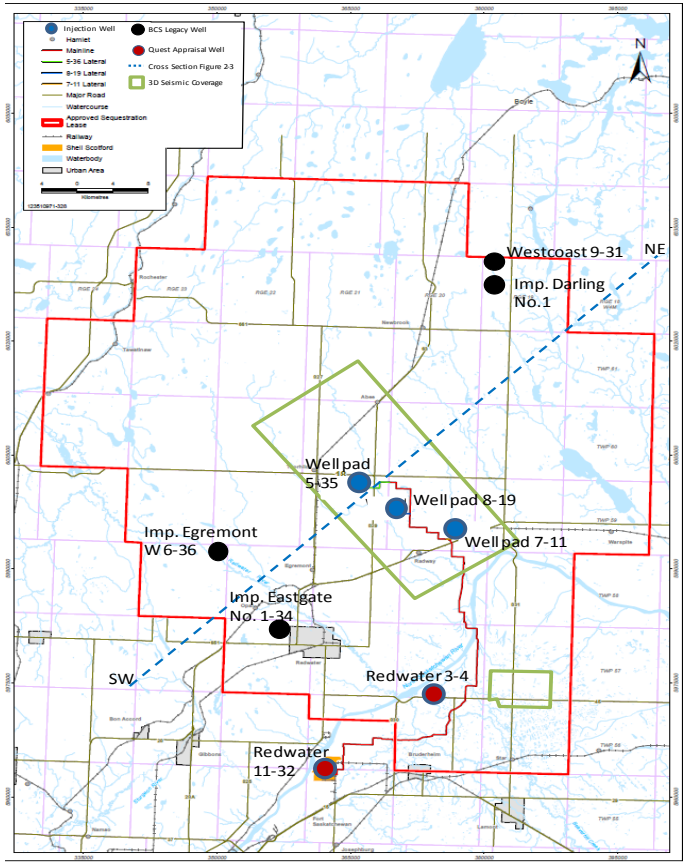
- **Joint Venture** among Shell (60%); Chevron (20%); and Marathon (20%)
- Quest CCS Project - **fully integrated** CCS (capture, transport, storage, monitoring)



- **One million tonnes CO_2 per year** capacity for 25 years
- 1/3 **reduction** of Upgrader CO_2 emissions
  - equiv. to emissions from **250,000 cars** (per year)
- Project **Approval** – **Sept 2012**
- **Commercial** operation achieved – **Sept 2015**

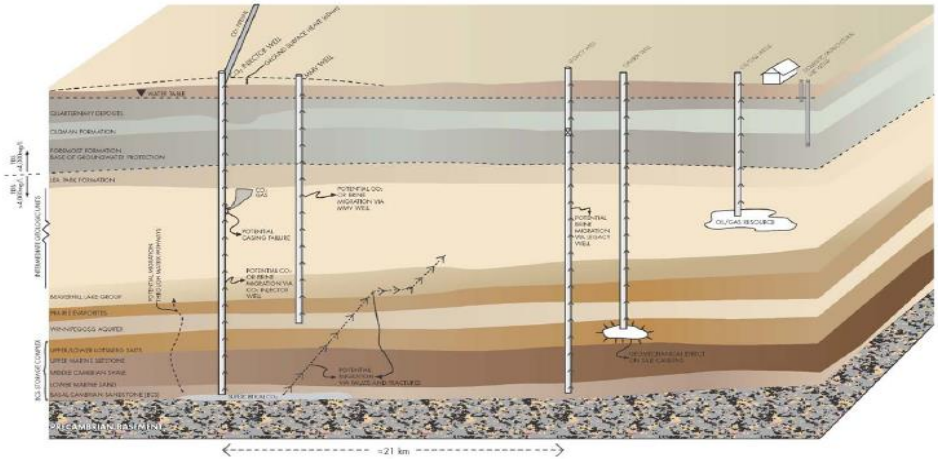
OVERVIEW

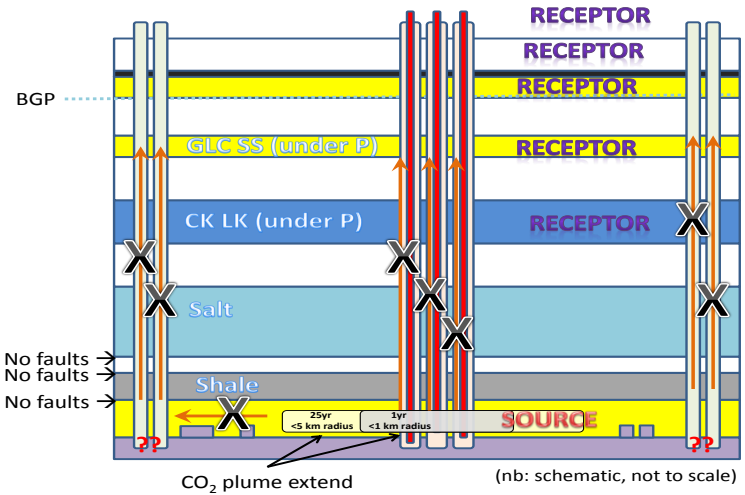
- Well infrastructure
  - 2 appraisal wells
    - (~ 2 km MD)
  - 3 injection wells
    - (~ 2 km MD)
  - 3 deep monitoring wells
    - (~ 1.7 km MD)
  - 9 groundwater monitoring wells
    - (< 0.2 km MD)



SITE SELECTION & CHARACTERIZATION

- **CSM** - Risks to containment





SITE SEL

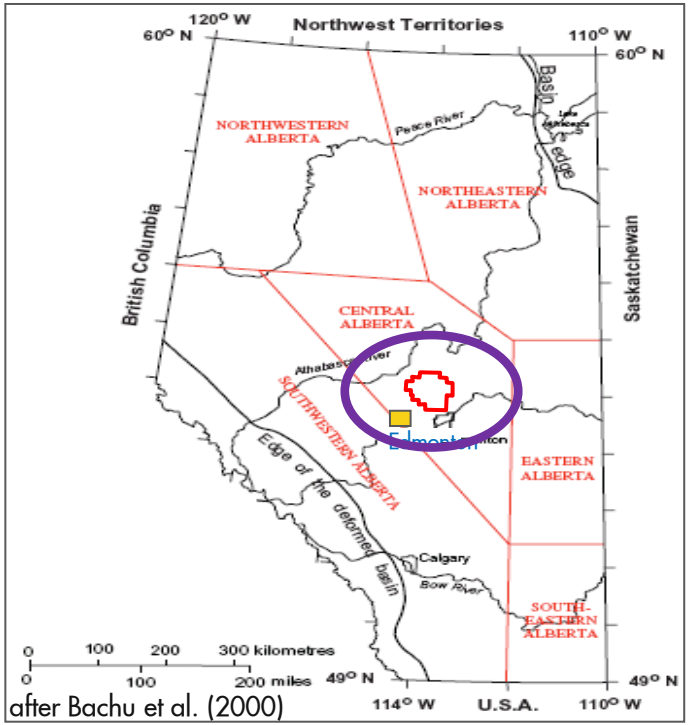
CCS - Criteria

Criterion Level	No.	CO2 Storage Property or Attribute: Criterion	Eliminate or Unfavourable	Preferred or favourable
Critical	1	**Reservoir Seal Pairs**, extensive and competent barrier to vertical flow	Poor discontinuous, faulted and/or breached	Intermediate and excellent, many pairs (multi-layered system)
	2	**Pressure** regime	Overpressure, pressure gradients greater than 14kPa/m	Pressure gradients less that 12 kPa/m
	3	**Monitoring** potential	Absent	Present
	4	Affecting **protected groundwater quality**	Yes	No
Essential	5	**Seismicity**	High	Moderate or less
	6	**Faulting & fracturing**	Extensive	Limited to moderate
	7	**Hydrogeology**	Short flow systems or compaction flow. Saline aquifers in communication with protected groundwater acquifers	Intermediate and regional scale flow
Desirable	8	**Depth**	<750-800m	> 800m
	9	Located within **fold belts**	yes	No
	10	Adverse **diagenesis**	Significant	Low to moderate
	11	**Geothermal** regime	Gradients >35 degC/km and/or high surface temperature	Gradients <35 degC/km and low surface temperature
	12	**Temperature**	<35 deg C	>35 deg C
	13	**Pressure**	< 7.5 Mpa	> 7.5 Mpa
	14	**Thickness**	< 20m	> 20m
	15	**Porosity**	< 10%	> 10%
	16	**Permeability**	< 20mD	> 20mD
	17	**Caprock** thickness	< 10m	> 10m
	18	**Well Density**	High	Low to moderate

after IEA Greenhouse Gas R&D Programme (IEA GHG), "CCS Site Characterisation Criteria", 2009/10, July 2009.

SITE SELECTION & CHARACTERIZATION

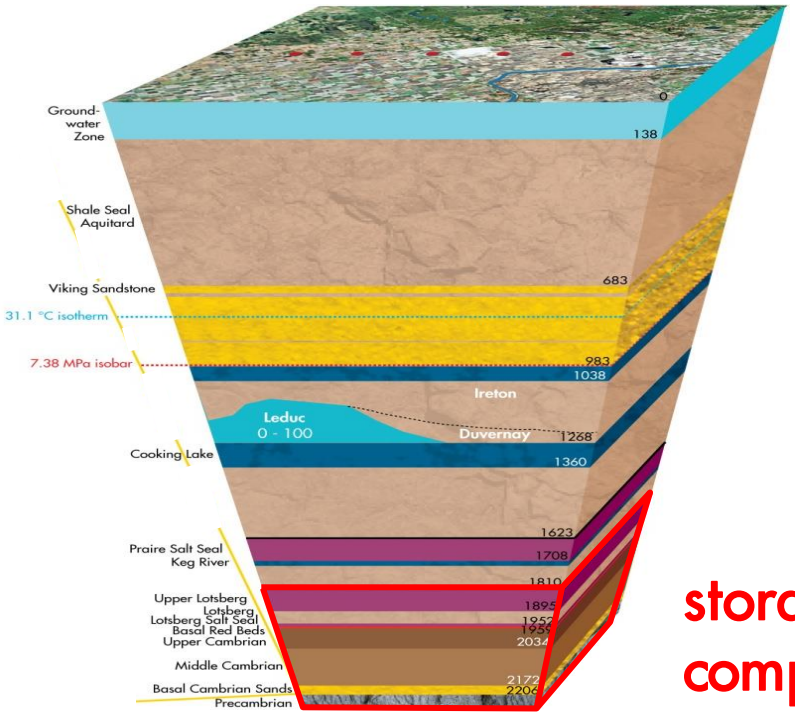
- **Ranking parameters**
  - Capacity
  - Injectivity
  - Containment



Central Alberta "Extremely Suitable" for CO_2 sequestration

SITE SELECTION & CHARACTERIZATION

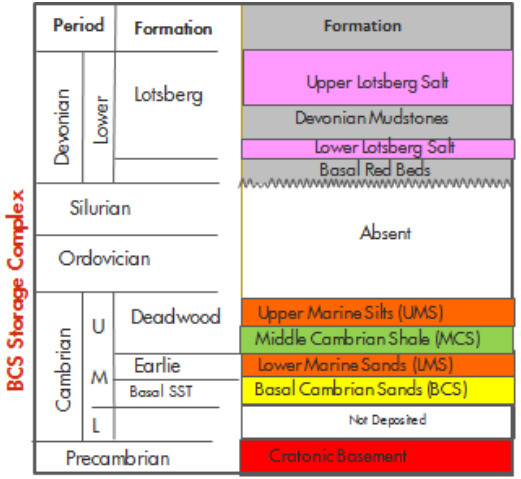
- **Target reservoir** – BCS: deep **saline aquifer** (~ 2km below ground)



Atmosphere
Biosphere
Hydrosphere

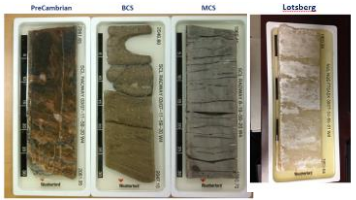
Geosphere

storage complex



target – reservoir

seals

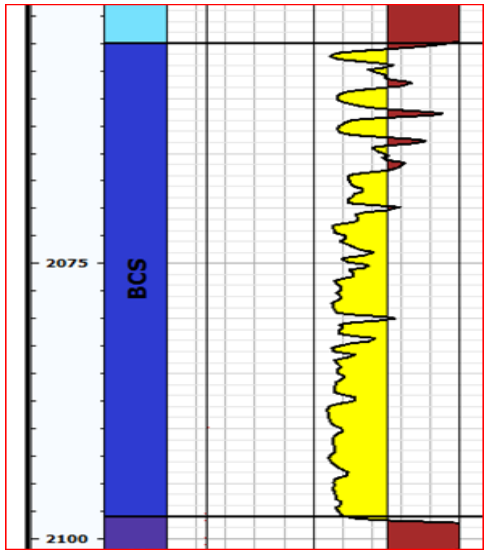


SITE SELECTION & CHARACTERIZATION

- **Target reservoir characteristics**

NW

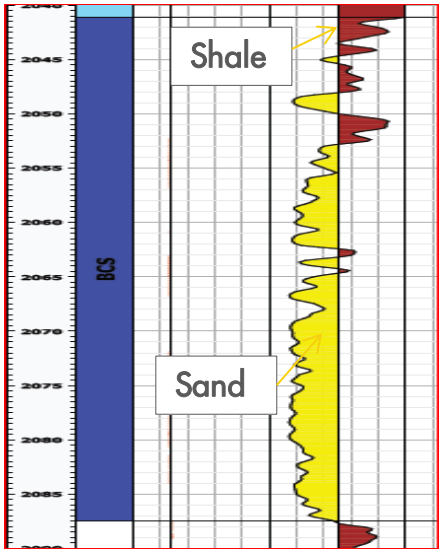
IW 5-35
(Gamma Ray Log)



Net Sand - 42m

Porosity – 16 %

IW 8-19
(Gamma Ray Log)

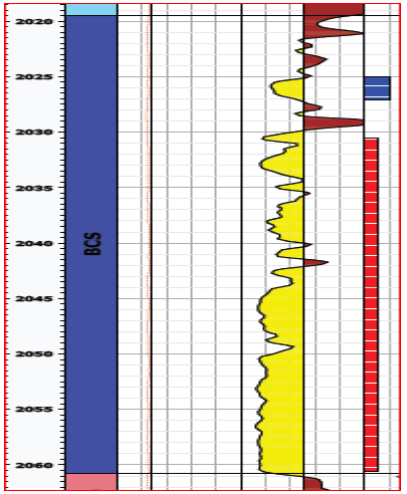


Net Sand - 39m

Porosity – 17 %

IW 7-11
(Gamma Ray Log)

SE



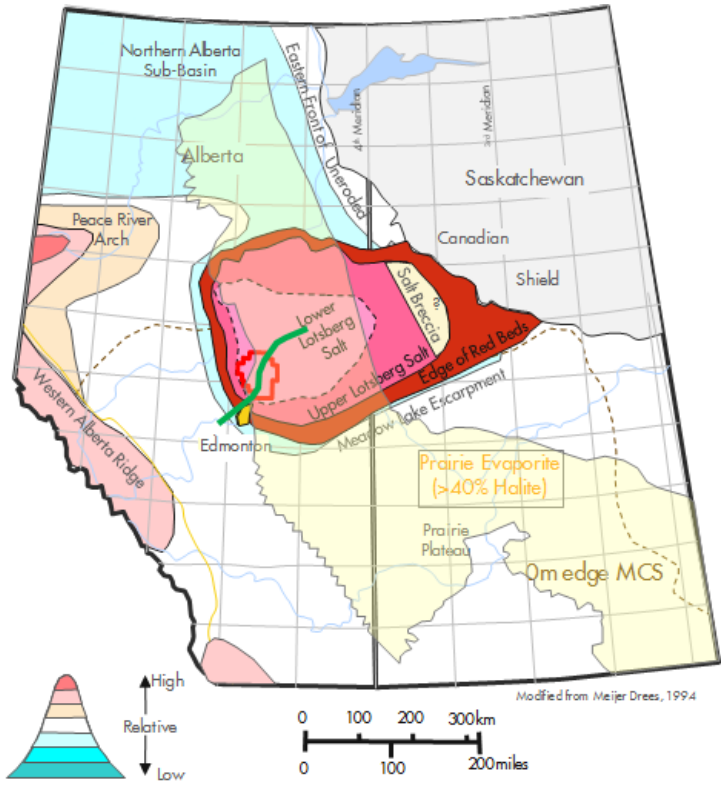
Net Sand - 38m

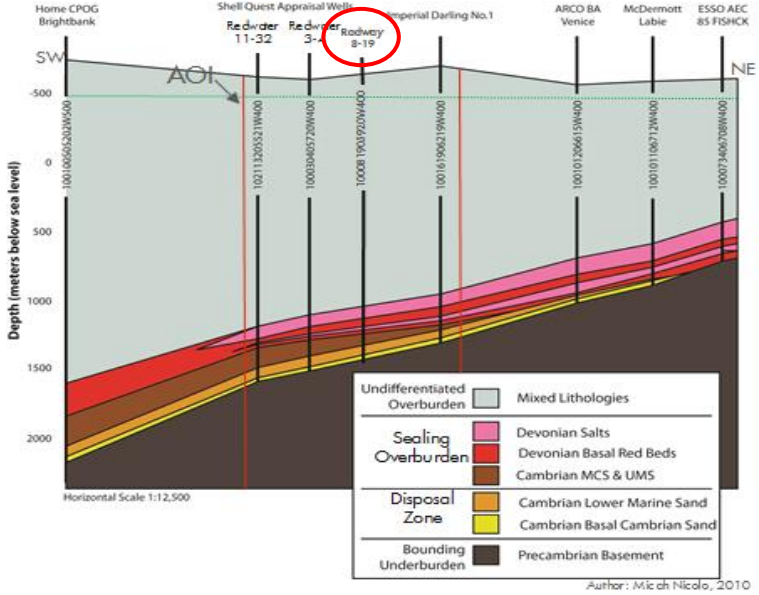
Porosity – 17 %

Nb: based on Vsh cut off = 0.35 and Porosity Cut Off = 0.1

SITE SELECTION & CHARACTERIZATION

- **Seals characteristics**



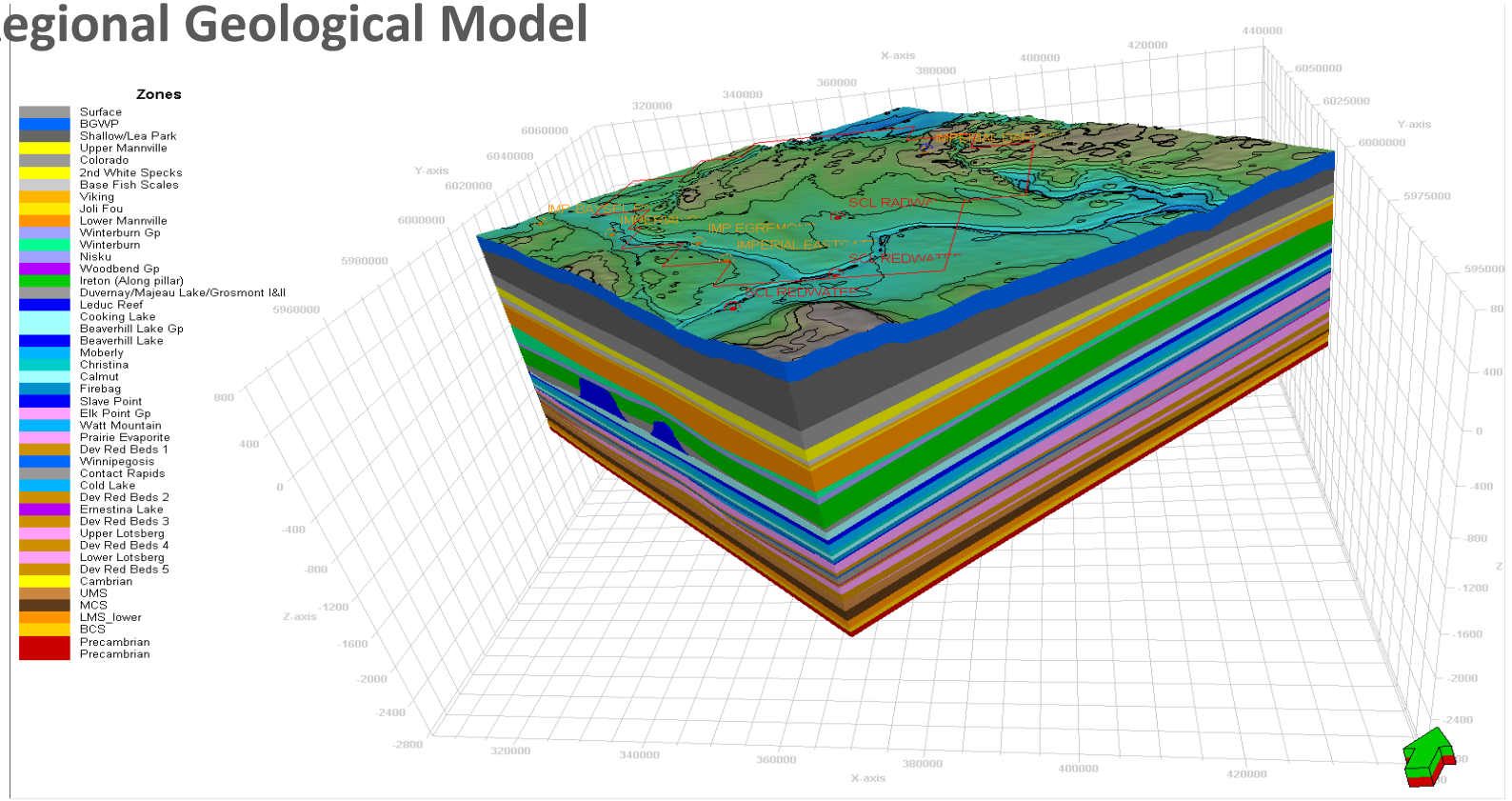


Radway 100/08-19-059-20W4/00

Formation thickness (m)	
Upper Lotsberg (~100% Halite)	84
Lower Lotsberg (~100% Halite)	34
Middle Cambrian Shale (MCS)	44

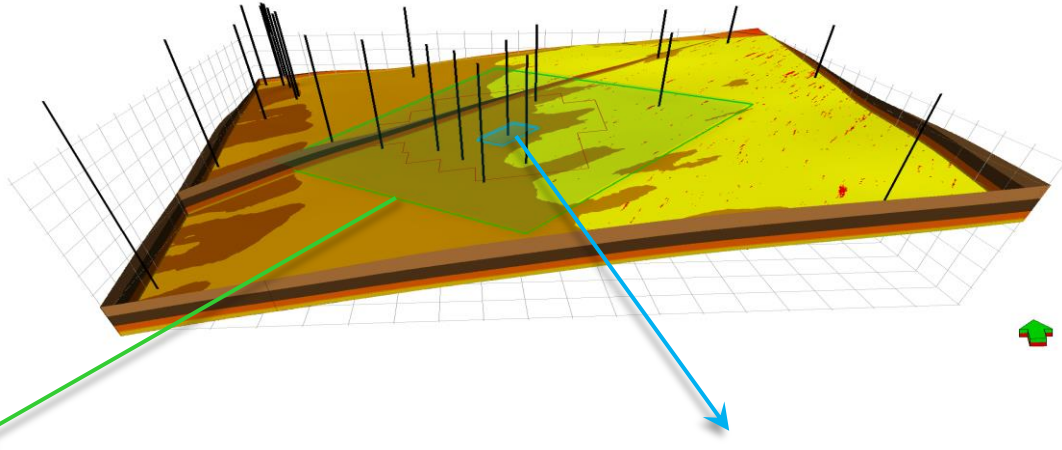
SITE SELECTION & CHARACTERIZATION

Regional Geological Model

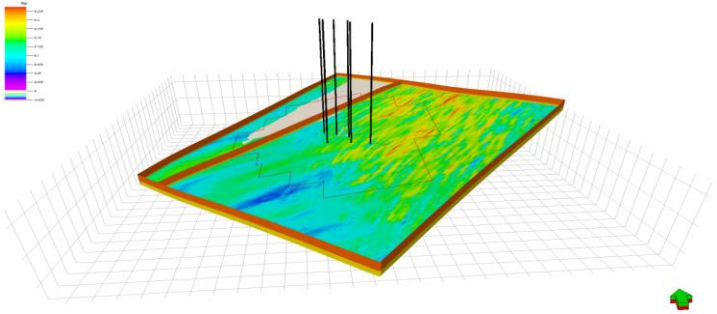


SITE SELECTION & CHARACTERIZATION

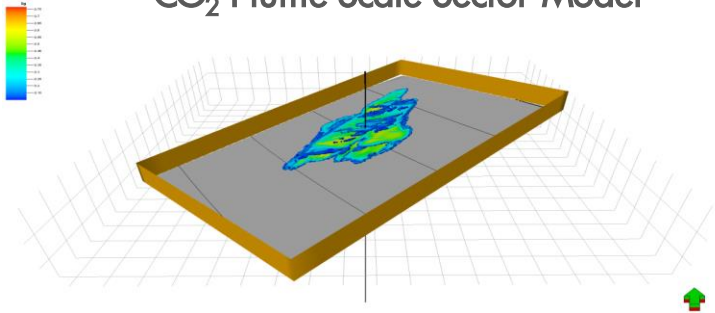
- **Modeling**
  - static – dynamic
  - geochemical,
  - geomechanical
  - etc.



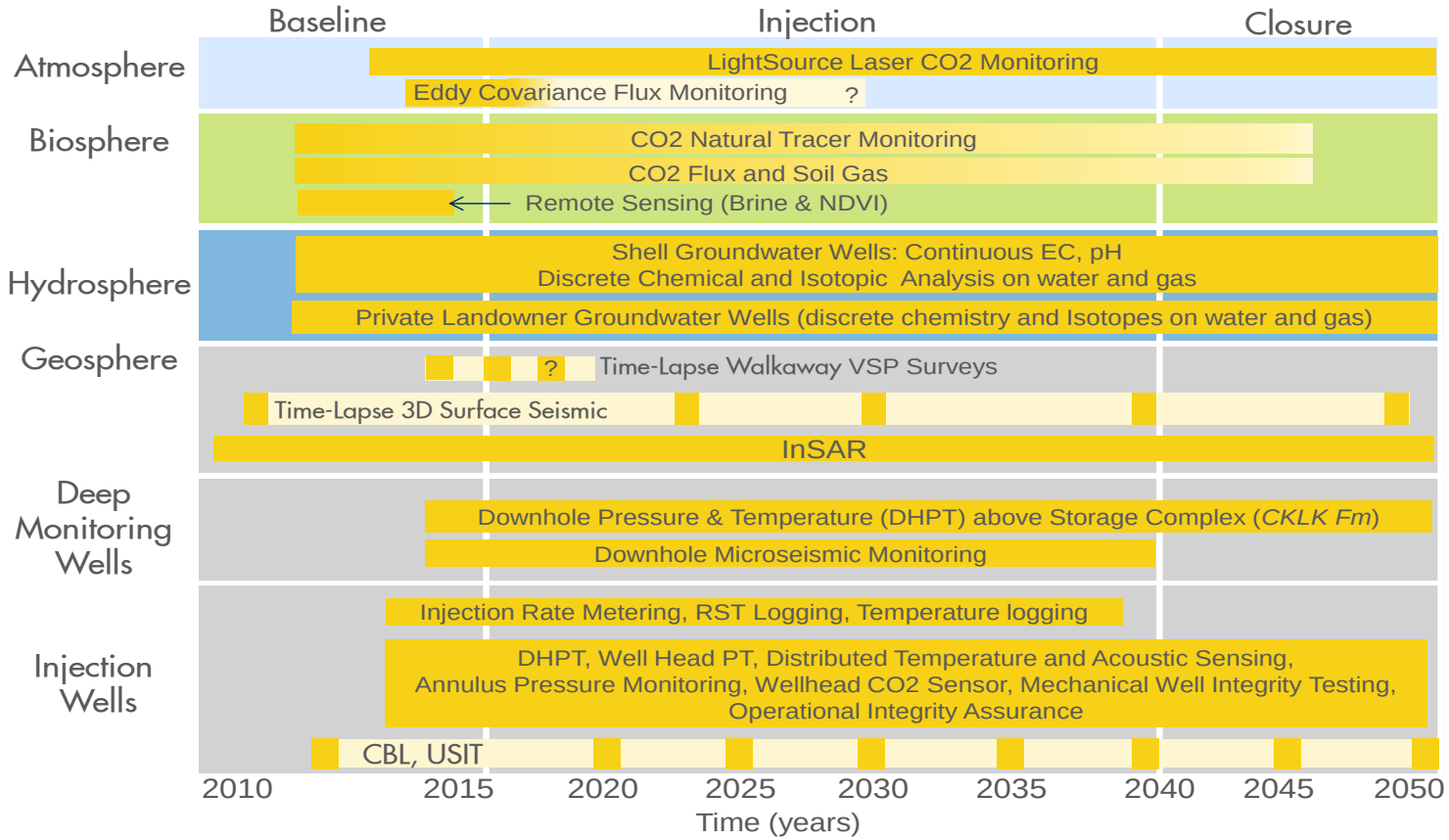
Pressure Scale Sector Model



CO_2 Plume Scale Sector Model



MMV PLAN

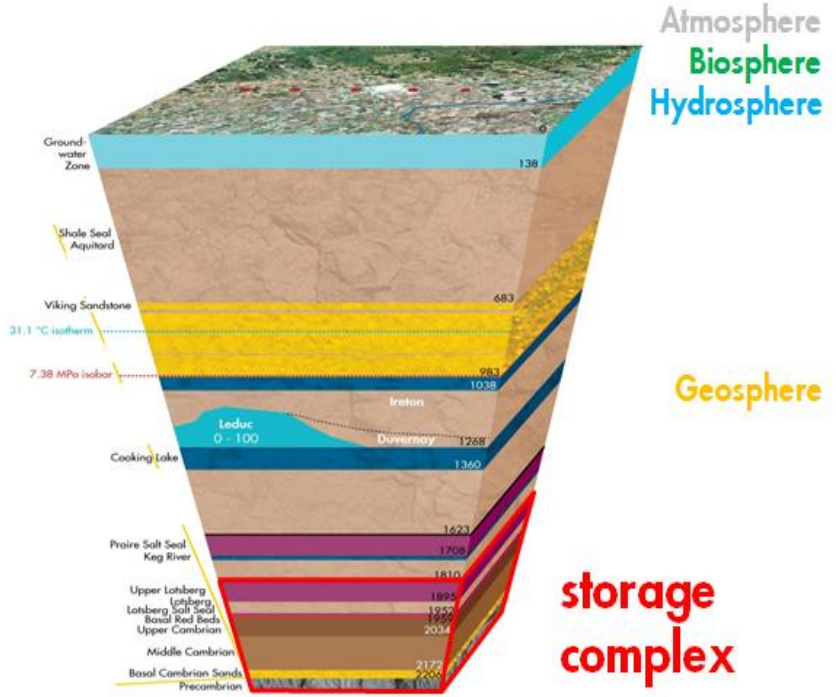

Baseline
Injection
Closure
Atmosphere
LightSource Laser CO2 Monitoring
Eddy Covariance Flux Monitoring
?
Biosphere
CO2 Natural Tracer Monitoring
CO2 Flux and Soil Gas
Remote Sensing (Brine & NDVI)
Hydrosphere
Shell Groundwater Wells: Continuous EC, pH
Discrete Chemical and Isotopic Analysis on water and gas
Private Landowner Groundwater Wells (discrete chemistry and Isotopes on water and gas)
Geosphere
?
Time-Lapse Walkaway VSP Surveys
Time-Lapse 3D Surface Seismic
InSAR
Deep Monitoring Wells
Downhole Pressure & Temperature (DHPT) above Storage Complex (CKLK Fm)
Downhole Microseismic Monitoring
Injection Wells
Injection Rate Metering, RST Logging, Temperature logging
DHPT, Well Head PT, Distributed Temperature and Acoustic Sensing,
Annulus Pressure Monitoring, Wellhead CO2 Sensor, Mechanical Well Integrity Testing,
Operational Integrity Assurance
CBL, USIT
2010
2015
2020
2025
2030
2035
2040
2045
2050
Time (years)

MMV PLAN

- **Ensure Containment:**

  Demonstrate 'security' of CO_2 storage

  - Verify absence of environmental effects
  - Detect early warning signs of unexpected loss of containment
  - Trigger of additional safeguards
  - Safety Critical – designed to ALARP



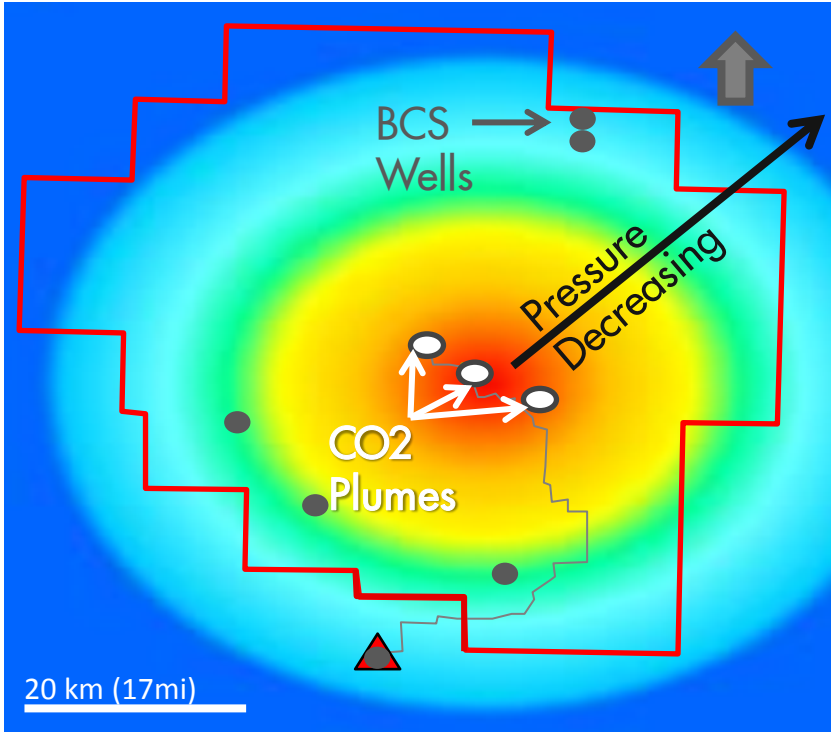
MMV PLAN

- **Ensure Conformance:**

  Indicate long-term effectiveness of CO_2 storage

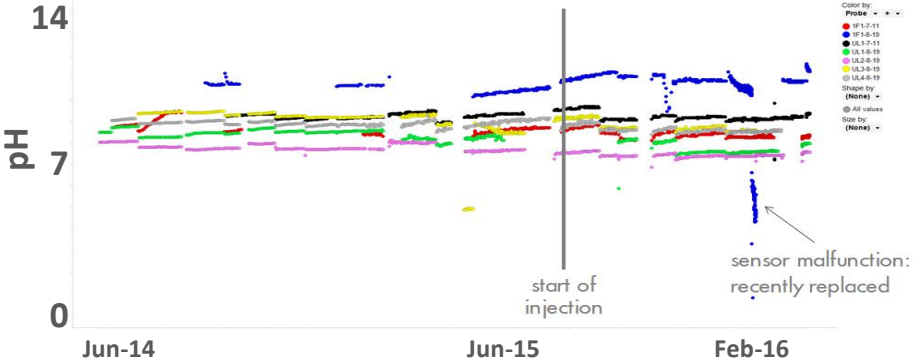
  - Validate, Calibrate and Update CO_2 plume and pressure predictions
  - Adapt injection and monitoring to optimize performance

Schematic: CO_2 Plumes and Area of Elevated Pressure

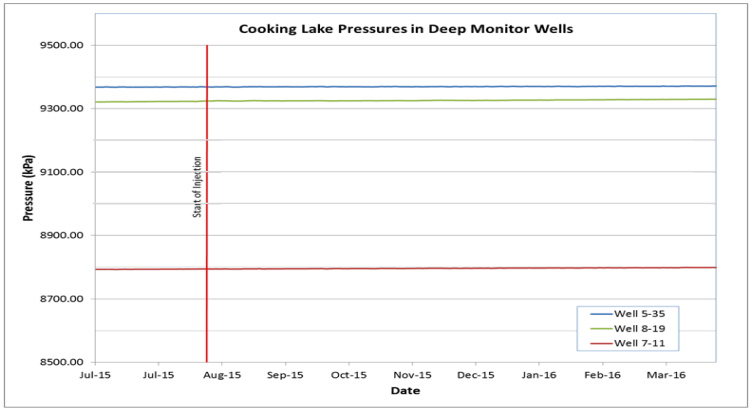


CURRENT STATUS

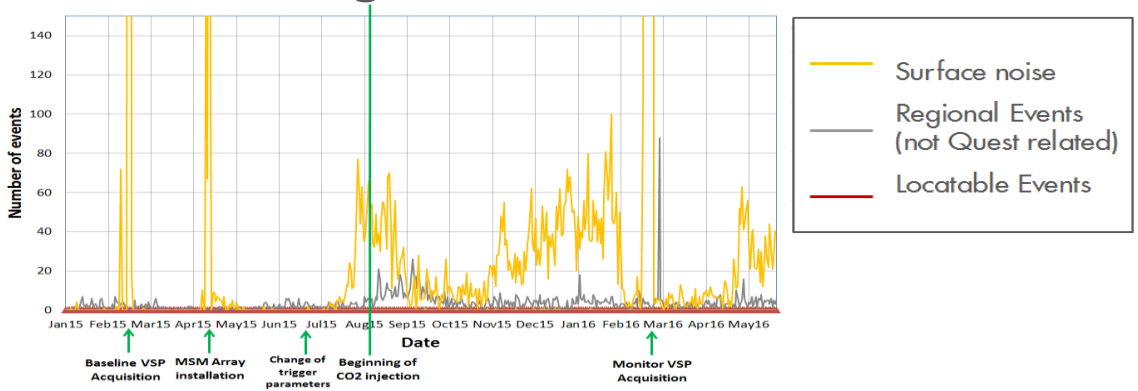
GW monitoring



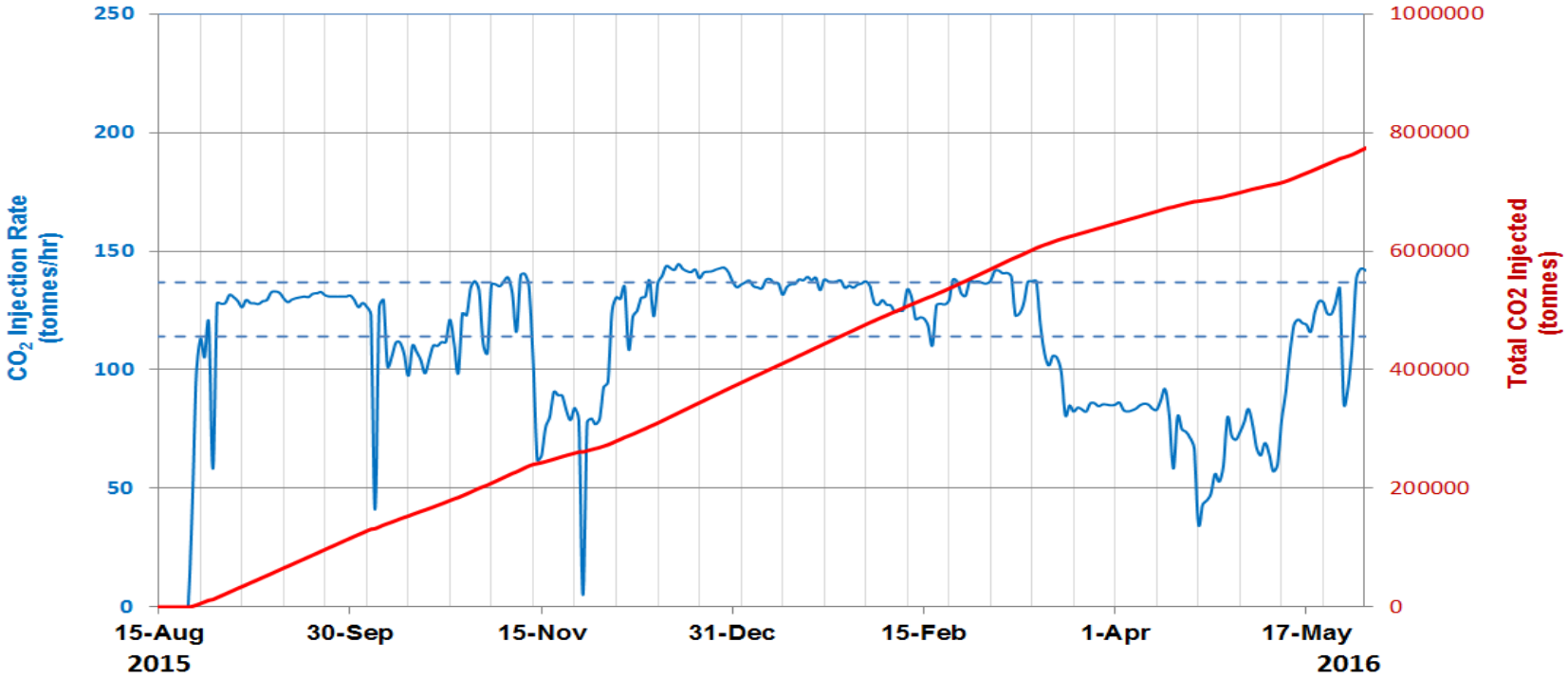
DHP monitoring



MS monitoring



CURRENT STATUS



ACKNOWLEDGEMENTS

- Government of Alberta, Department of Energy (DOE)
- Government of Canada, Natural Resources Canada (NRCan)
- Shell staff (Calgary, Houston, EU)
- 3rd party contractors
- Partners: Chevron Canada Ltd & Marathon Oil Canada