# Overview, Status, and Future of the Fort Nelson CCS Project

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## Overview

The Plains $CO_2$ Reduction (PCOR) Partnership, led by the Energy & Environmental Research Center (EERC), and Spectra Energy Transmission (SET) are investigating the feasibility of a carbon capture and storage (CCS) project to mitigate carbon dioxide ($CO_2$) emissions produced by SET's Fort Nelson Gas Plant (FNGP). The FNGP is located near the town of Fort Nelson in northeastern British Columbia, Canada. The gas stream produced by the FNGP will include up to 5% hydrogen sulfide (H2S) and a small amount of methane (CH4) and, as such, is referred to as a "sour" $CO_2$ stream. The sour $CO_2$ gas stream would be injected into a deep saline carbonate formation.

The Fort Nelson demonstration project provides a unique opportunity to develop a set of cost-effective, risk-based monitoring, verification, and accounting (MVA) protocols for large-scale (>1 million metric tons a year) storage of sour $CO_2$ in a deep saline formation. The role of the PCOR Partnership is to provide the project with reservoir modeling and simulation, risk assessment of subsurface technical risks, and an MVA plan to address these risks. The PCOR Partnership applies a philosophy that combines geologic characterization, modeling, risk assessment, and MVA strategies into an iterative process to produce superior-quality results during the project feasibility and development periods. Elements of any of these activities are crucial for understanding or developing the other activities (Gorecki and others, 2012).

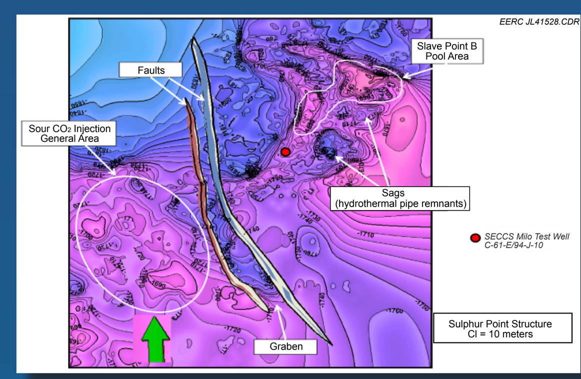
## Status

To date, a variety of site characterization, modeling, risk assessment, MVA planning, regulatory permitting, and public outreach activities have been conducted. Collection of baseline data for shallow groundwater characteristics has been initiated. A comprehensive suite of existing well data, 2-D and 3-D seismic surveys, log analyses, and core testing results have been acquired and used to create static geologic models. The static geologic models have supported dynamic modeling, including history matching and the development of predictive simulations for selected injection scenarios. Results thus far suggest that the geology and hydrogeology in the vicinity of the FNGP are amenable to long-term geologic storage of $CO_2$. The output from the characterization and modeling exercises has provided the basis for two iterations of a comprehensive risk assessment of the geologic risks associated with the Fort Nelson CCS project. The combined results of the characterization, modeling, and risk assessment activities provide a basis for MVA planning and will ultimately support the selection of a site-specific injection strategy. Key permitting application documents have been developed for submission to British Columbia regulatory authorities. A poster and fact sheet have been developed to provide supporting materials for public outreach efforts.

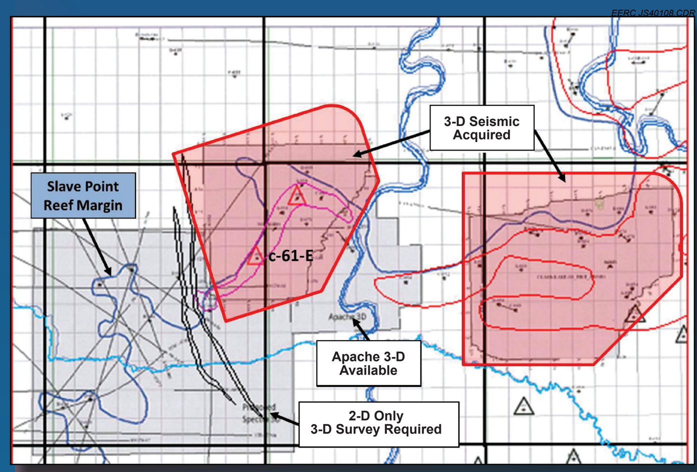
## Future

Future plans call for drilling an additional exploration well and collecting new 3-D seismic data. This will be followed by further refinement of the static model and new dynamic simulations, which will support the selection of a final injection strategy. Once a final injection strategy has been defined, the risk assessment will once again be updated, which will, in turn, be used to guide a specific MVA strategy. The updated MVA plan will include specific technologies, spatial locations of measurements, monitoring schedule, and baseline data necessary to address critical project risk and regulatory requirements and identify any deviations from expected conditions in a timely manner. Although specific techniques and procedures may change as the project proceeds, the project's integrated philosophy of geologic characterization, modeling, and risk assessment will ensure that MVA strategies remain fit for purpose and cost-effective, with the greatest potential for success throughout the project's lifetime.

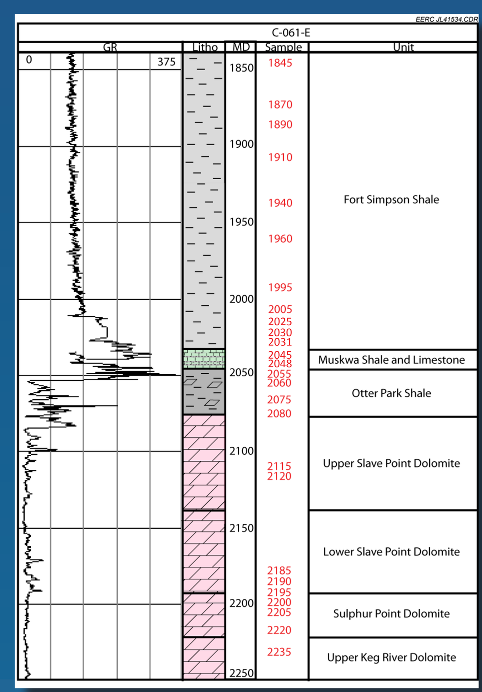
## Characterization



A structure map of the top of the Sulphur Point Formation in the vicinity of the existing exploratory well.




Acquired and available seismic survey locations within the Fort Nelson study area.




Gamma and lithology logs from existing exploratory, with marked sample locations from the Fort Simpson, Muskwa, Otter Park, Slave Point, Sulphur Point, and Keg River Formations.

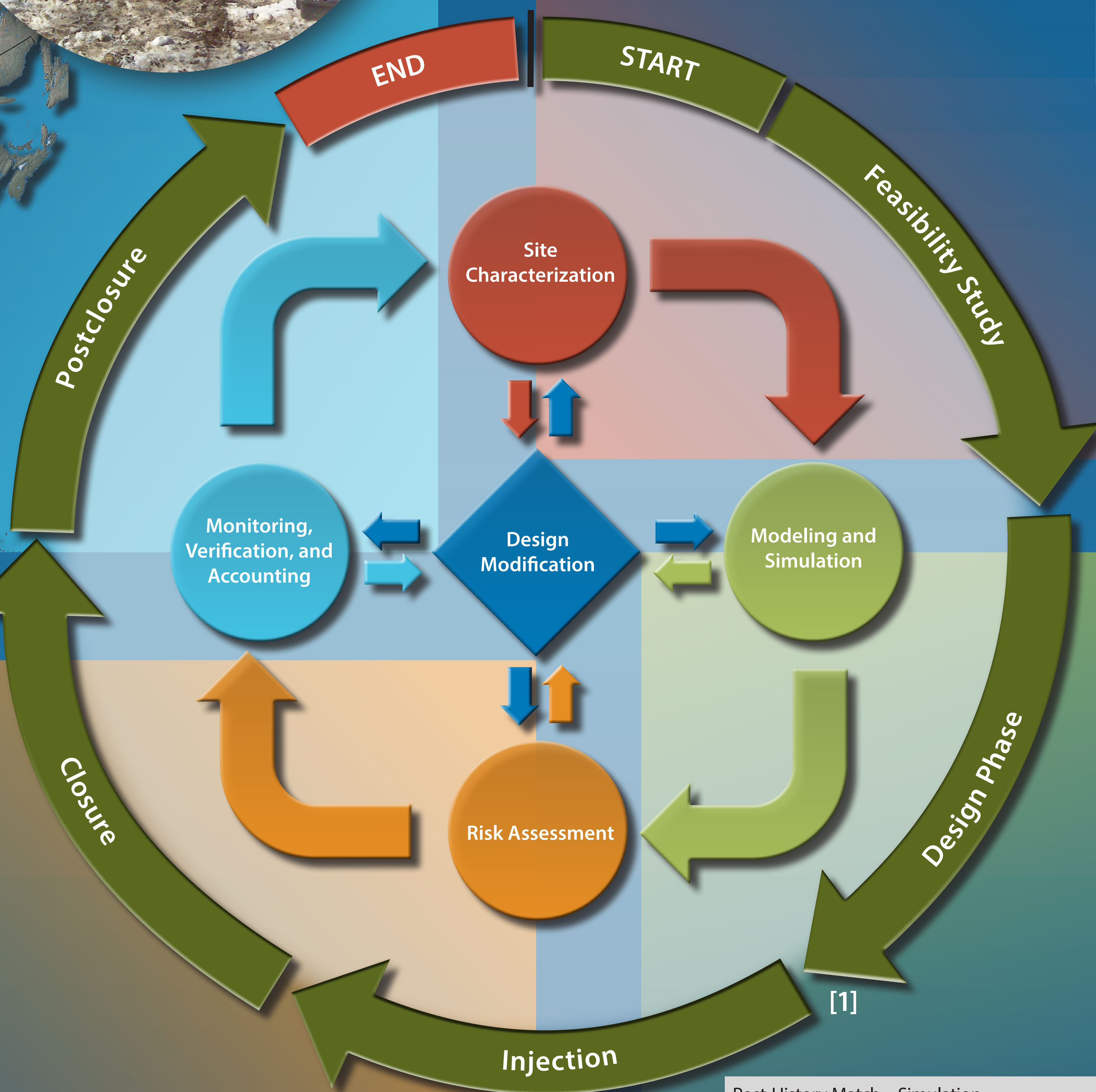
Core sample of the Muskwa formation collected from the exploratory well. The Muskwa Formation is a shale that will serve as a seal.

Effective Storage Volume of the 2000-km² Study Area at the Fort Nelson CCS Site

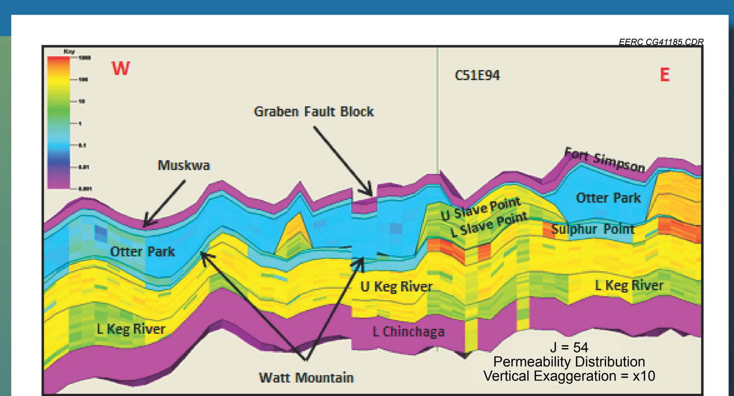
| Formations | Pore Volume, m³ | Storage Mass* (E = 1.00%), tonnes | Storage Mass* (E = 2.00%), tonnes |
|---|---|---|---|
| Slave Point | 4,340,000,000 | 18,000,000 | 36,000,000 |
| Sulphur Point | 2,920,000,000 | 12,100,000 | 24,200,000 |
| Keg River | 22,200,000,000 | 92,100,000 | 184,200,000 |
| Summary | 29,460,000,000 | 122,200,000 | 244,400,000 |

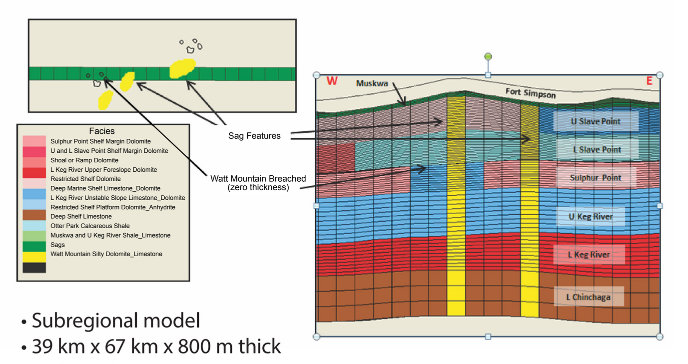
*A $CO_2$ density of 415 kg/m³ was used to calculate the storage mass (average $CO_2$ density in the reservoir).

## MVA

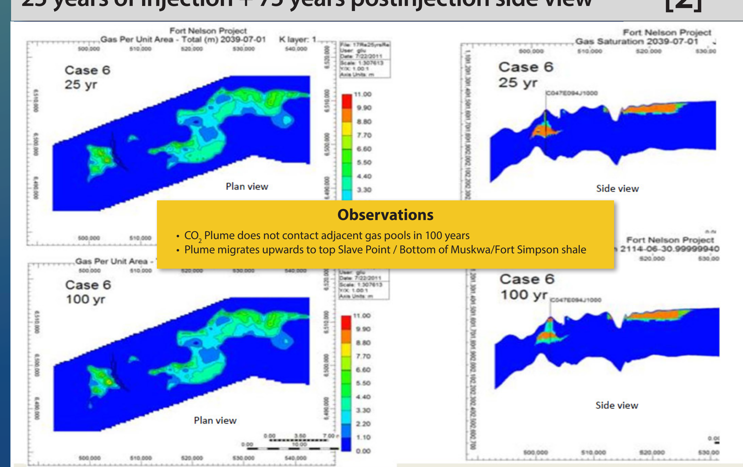

## Modeling




- Subregional model
- 39 km x 67 km x 800 m thick
- 13 Domains
- Ten Formations

Post-History Match – Simulation
25 years of injection + 75 years postinjection side view [2]

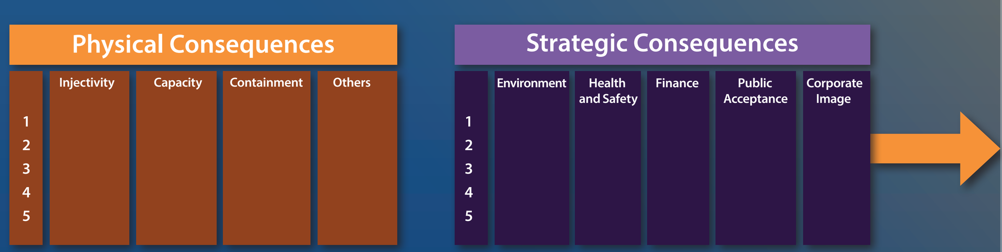



### Model Observations

- Sufficient storage capacity to accommodate target injection volumes for 25 years.
- $CO_2$ plume does not contact the adjacent gas pools during the 100- year simulation period.
- Good pressure dissipation in open reef system.
- Injection pressure increase approximately equal to the before- production 1961 area pressure.

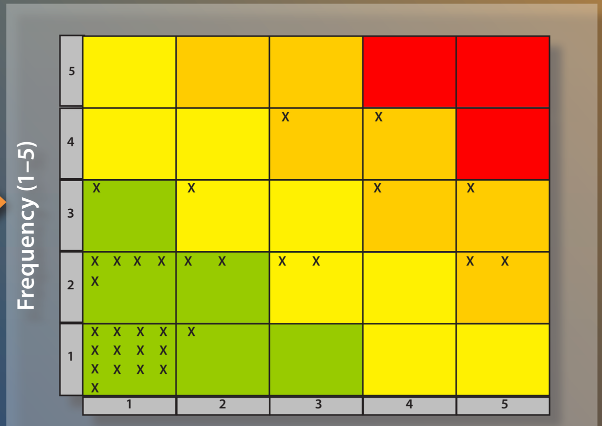
## Risk

The risk management process used for managing the subsurface technical risks of the Fort Nelson CCS project, complies with International Organization for Standardization (ISO) 31000, an international standard for risk management. The risk management methodology integrated the ISO 31000 framework with existing Spectra Energy risk management processes, practices, and risk tolerance standards. The scope of the risk management work performed included all subsurface, technical risks resulting from the geologic storage of $CO_2$.




Injectivity Transfer Matrix

| | E | H&S | F | PA | CI |
|---|---|---|---|---|---|
| 1 | | | 1 | | 2 |
| 2 | | | 2 | | 3 |
| 3 | | | 3 | | 4 |
| 4 | | | 4 | | 5 |
| 5 | | | 5 | | 5 |




The 31 risks identified have been grouped into four main categories:

1. Loss of injectivity (local pressure issues or geochemical reactions)
2. $CO_2$ migration and adverse pressure effects on existing production
3. Loss of containment – brine to groundwater via old wells
4. Lack of capacity – restriction by regulation

Next Steps

1. Gather more data as required to improve reservoir characterization combined with reservoir sensitivity modeling – next RA report
2. MVA Technology Screening – Risk based and assessed (Bayesian Analysis Techniques) to optimize selection and confidence in risk management

## References

[1] Gorecki, C.D., Liu, G., Bailey, T.B., Sorensen, J.A., Klapperich, R.J., Braunberger, J.R., Steadman, E.N., and Harju, J.A., The role of static and dynamic modeling in the Fort Nelson CCS Project: Paper 375 presented at the International Conference on Greenhouse Gas Technologies (GHGT-11), Kyoto, Japan, November 18–22, 2012, 8 p.

[2] Gorecki, CD, Sorensen, JA, Klapperich, RJ, Botnen, LS, Steadman, EN, and Harju, JA. A risk-based monitoring plan for the Fort Nelson feasibility project. Paper CMTC 151349 presented at the 2012 Carbon Management Technology Conference, Orlando, Florida, USA, February 7–9, 2012, 14 p.

## Acknowledgment

This material is based upon work supported by the U.S. Department of Energy National Energy Technology Laboratory under Award No. DE-FC26-05NT42592.

PCOR Partnership 2003 – Present

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