Development of a Monitoring, Verification, and Accounting Plan for a Potential CCS Project at Fort Nelson, British Columbia, Canada

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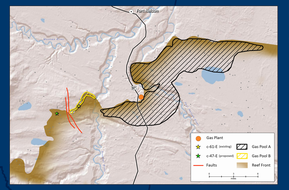
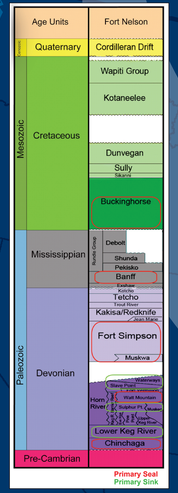
The Plains CO_2 Reduction (PCOR) Partnership and Spectra Energy Transmission (SET) are investigating the feasibility of a carbon capture and storage (CCS) project to mitigate CO_2 emissions produced by SET's Fort Nelson Gas Plant (FNGP) in northeastern British Columbia, Canada. If a CCS project is determined to be feasible, the CO_2 will be injected into a deep saline carbonate formation. Baseline characterization data have been collected on potential injection target and sealing formations and used to create static petrophysical models of potential CO_2 storage reservoirs and conduct dynamic simulation modeling of potential injection scenarios. The baseline data and initial modeling results were then used to conduct a risk assessment of potential operational scenarios. While a final injection strategy has not yet been determined, a draft monitoring, verification, and accounting (MVA) plan has been developed using assumptions based on those previous characterization, modeling, and risk assessment efforts. The draft MVA plan covers the surface, near-surface, and deep subsurface environments in the area of the FNGP and includes specific technologies, spatial locations of measurements, a 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. The project's integrated philosophy of geologic characterization, modeling, and risk assessment will ensure that MVA strategies remain fit for purpose and cost-effective. The key elements of the proposed draft Fort Nelson MVA plan have been considered and presented in the context of how they individually and/or collectively address the guidelines enumerated in the Canadian Standards Association (CSA) standard for geologic storage of CO_2.

PCOR Partnership 2003 – Present

Fort Nelson British Columbia, Canada

The Fort Nelson CCS project location is remote, with the site being accessible only in winter using an ice bridge and ice roads. Cold weather gear is essential. Additionally, snowmobiles may be required to get sample equipment to the shallow groundwater wells.

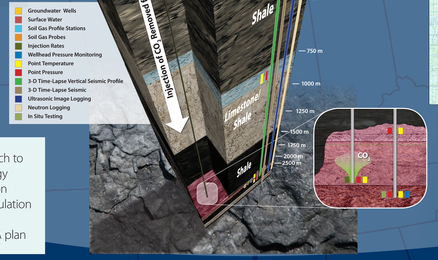




Baseline Characterization

- 93 wells in study area
- Historical 2-D and 3-D seismic
- Hydrogeological studies
- Test well – c-61-E
  - Core and cuttings
  - Formation pressures
  - Formation fluids
  - Water injection testing
  - Cap rock integrity testing
  - Solubility testing
  - Relative permeability testing
  - Hg injection capillary pressure tests
  - Geochemical reactivity testing

MVA



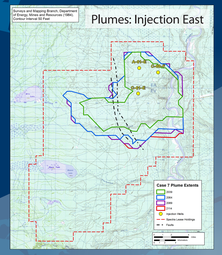
- Groundwater Wells
- Surface Water
- Soil Gas Profile Stations
- Soil Gas Probes
- Injection Rates
- Wellhead Pressure Monitoring
- Point Temperature
- Point Pressure
- 3-D Time-Lapse Vertical Seismic Profile
- 3-D Time-Lapse Seismic
- Ultrasonic Image Logging
- Neutron Logging
- In Situ Testing

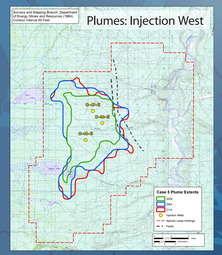
MVA Approach

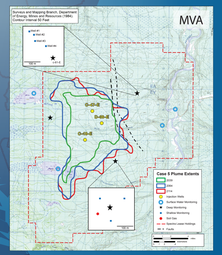
- Risk-based approach to define MVA strategy
- Site characterization
- Modeling and simulation
- Risk assessment
- Cost-effective MVA plan

The second-round risk assessment expanded the first-round risk assessment by addressing the relative project risks associated with two injection locations: a new proposed drilling location (west) and the original test well location (east). As suggested by the results of the first-round risk assessment, the Injection West location was chosen to reduce the likelihood that injection would impact gas pools before the end of their productive life. The draft MVA plan was developed based on the Injection West scenario.

Risk Assessment







50-year Injection Scenario

Injection
- Three injection wells
  - Sulphur Point Formation
- 120-MMscf/d injection rate
  - 2.5 million tons/year

Monitoring Elements
- Three deep monitoring wells
  - Debolt Formation
  - Sulphur Point Formation
- Shallow groundwater-monitoring wells in vicinity of deep monitoring wells and injection wells
- Surface water sampling
  - Lakes
  - Rivers
- Soil gas monitoring in vicinity of deep monitoring wells and injection wells

Characterization and Modeling

- Site screening
- Site selection
- Site characterization and assessment
  - Geological and hydrogeological characterization of the storage unit
  - Characterization of confining strata
  - Baseline geochemical characterization
  - Baseline geomechanical characterization
  - Well characterization
- Modeling for characterization
  - Geologic static model
  - Flow modeling
  - Geochemical modeling
  - Geomechanical modeling

Risk Management

- Objectives
- Context
  - Elements of concern
  - System model
  - Identification of context
- * Risk management plan
- Risk assessment
  - Risk identification
  - Risk analysis
  - Risk evaluation
- Planning and review of risk treatment
- Review and documentation
- * Risk communication and consultation
  - * Performance metrics
  - * Scope of risk communication and consultation activities

Fort Nelson MVA Compared to the CSA Guidelines

- Thoroughly addressed
- Partially addressed
- * Spectra to determine

Monitoring and Verification

- Purpose
- M&V program periods
  - Preinjection period monitoring
  - Injection period monitoring
  - Closure period monitoring
  - * Postclosure period monitoring
- M&V program objectives
- M&V program design
  - Procedures and practices
  - Required specifications
  - Recommended specifications
  - * Contingency monitoring

Fort Nelson MVA will be challenging but it can be done.

General Conclusions

Climate, terrain, and remoteness will present significant challenges:
- Limited access means fewer sampling locations and events.
- Short work season means MVA technology installation will be expensive and require longer lead times for planning and elevated levels of coordination.
- Some MVA technologies will be severely hampered.
- These limitations may preclude Fort Nelson CCS operations from fully implementing many recommended protocols/technologies but should not prevent the application of required protocols/technologies.

If it were to go forward, the Fort Nelson CCS project would need to elaborate on the following items in order to be compliant with the CSA guidelines for geologic storage of CO_2:
- Geochemical and geomechanical modeling
- Characterization of neighboring wellbores with respect to wellbore integrity and their potential to serve as points of leakage
- Risk management and risk communication plans
- Postclosure and contingency MVA plans
- Determination of performance metrics
- Detailed schedules for deep and shallow MVA activities
- Detailed schedules for reporting

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