PMD 13-P1.1D

File / dossier : 8.01.07
Date: 2013-08-27
Edocs: 4191020

Supplementary Information

Presentation from Ontario Power Generation Inc.

On Site Characterization

In the Matter of

Ontario Power Generation Inc.

Proposed Environmental Impact Statement for OPG's Deep Geological Repository (DGR) Project for Low and Intermediate Level Waste

Joint Review Panel

September 16 to October 12, 2013

Renseignements supplémentaires

Présentation d' Ontario Power Generation Inc.

Sur La caractérisation du site

À l'égard de

Ontario Power Generation Inc.

Étude proposée pour l'énoncé des incidences environnementales pour l'Installation de stockage de déchets radioactifs à faible et moyenne activité dans des couches géologiques profondes

Commission d'examen conjoint

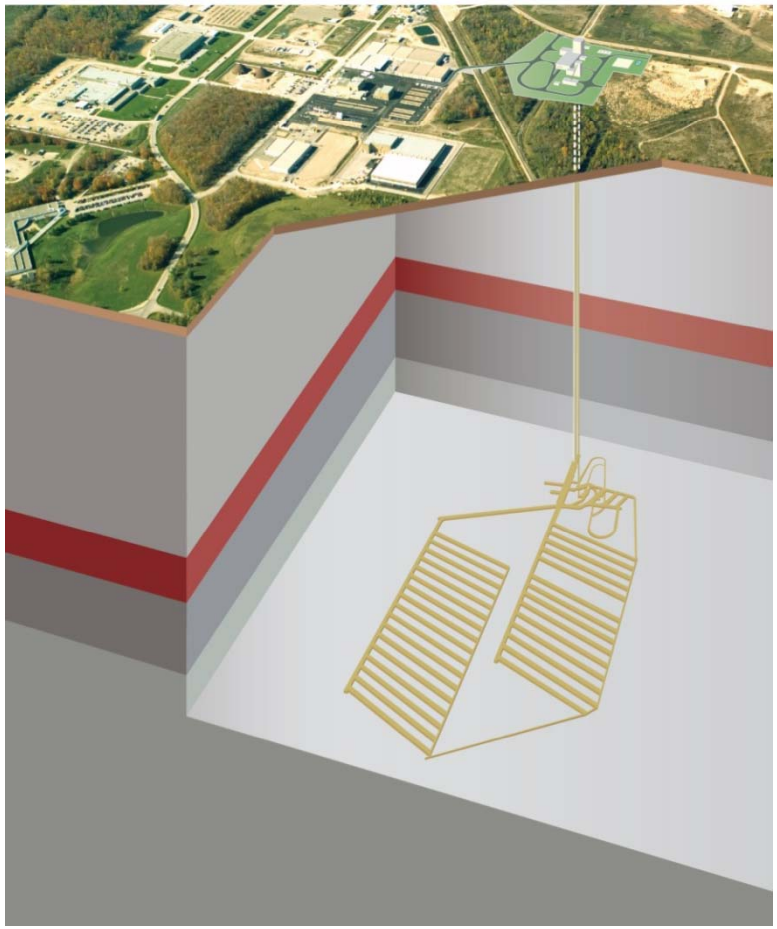
Du 16 septembre au 12 octobre 2013

Canada

OPG's L&ILW DGR Joint Review Panel Hearing

Geology: Site Characterization

September 18, 2013



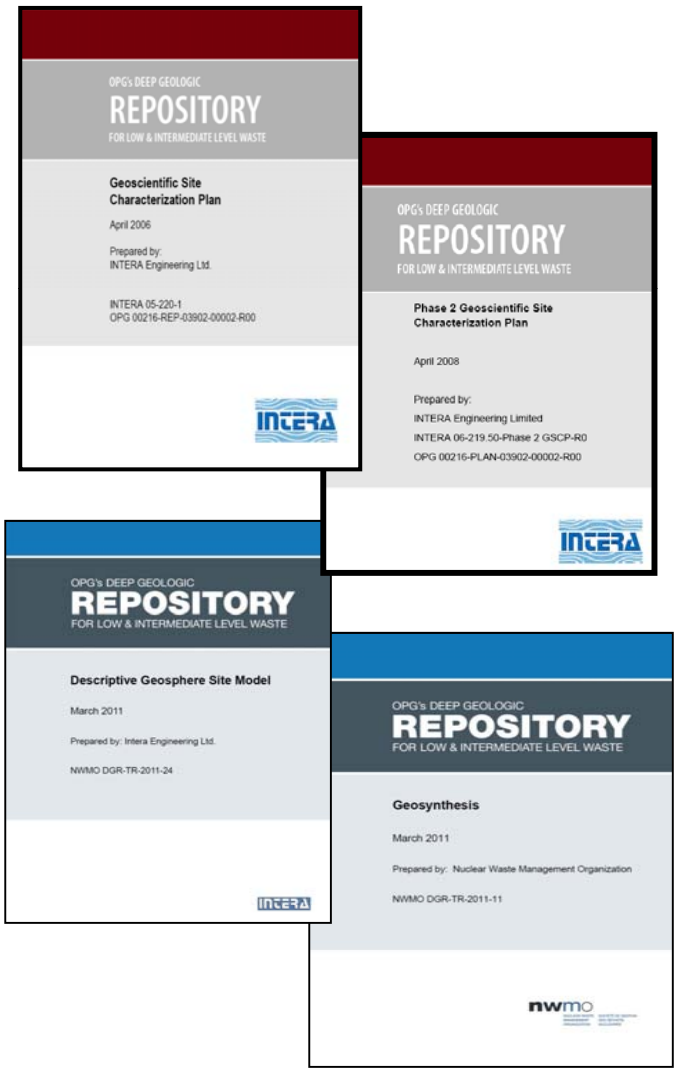
ONTARIO POWER GENERATION

Presentation Outline

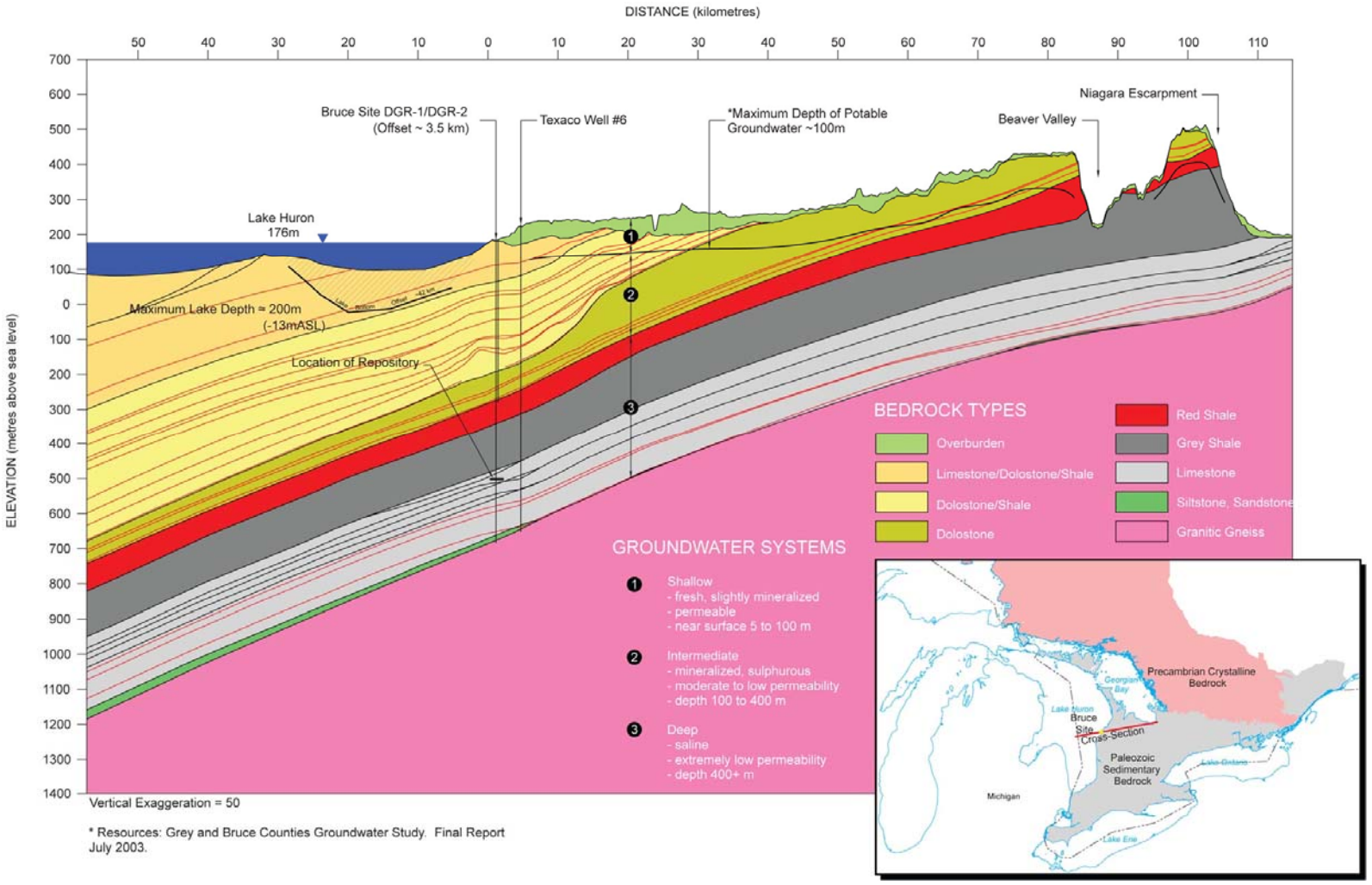
- ❑ Geologic Investigations: Approach
- ❑ Geosciences Hypothesis Testing/Team
- ❑ Site Characterization Field Activities
- ❑ Geosynthesis: Site Understanding/Features
- ❑ Geoscientific Verification Plan
- ❑ Conclusions

Geoscience Investigations: Approach

- Geotechnical Feasibility Study (2003)
- Bruce Nuclear Site Studies (2006-2010)
  - Site-specific field studies
    - Phase I (2006-2008)
    - Phase II (2008-2010)
  - Geosynthesis (2006-2010)
- Geoscience Assessment Approach
  - Hypothesis testing
  - Multiple lines of reasoning
- International Geoscience Experience
  - Field/laboratory methods/tools
- Independent Technical Oversight
  - Geoscience Review Group
  - Peer review (Phase I/II)



Geosphere Model



* Resources: Grey and Bruce Counties Groundwater Study. Final Report July 2003.

Geoscience Hypotheses

Predictable: horizontally layered, undeformed sedimentary shale and limestone formations of large lateral extent

Multiple Natural Barriers: multiple low permeability bedrock formations enclose and overlie the DGR

Contaminant Transport Diffusion Dominated: deep groundwater regime is ancient and shows no evidence of glacial perturbation or cross-formational flow

Natural Resource Potential Low: commercially viable oil and gas, salt, and base metal reserves not present

Seismically Quiet: located in a seismically quiet portion of the craton; comparable to stable Canadian Shield setting

Geomechanically Stable: selected DGR limestone formation will provide stable, virtually-dry openings

Shallow Groundwater Resources Isolated: near-surface groundwater aquifers isolated

Geoscience Team: Contributions

Geosynthesis
AECOM Canada

Descriptive Geosphere Site Model
Geofirma Engineering

Technical Oversight
- Geoscience Review Group (**GRG**)
  - Jacques Delay (Andra: France)
  - Dr. Joe Pearson (USA)
  - Dr. Andreas Gautschi (Nagra: Switzerland)
  - Prof. Derek Martin (U. of Alberta)

Specialists
- **Itasca** – *geology, 3DGFM, Geomechanical Stability Analysis*
- **Worthington Groundwater** – k*arst*
- **Fracture Systems** – Excavation Damage Zone *(EDZ)*
- **AMEC Geomatrix** – *Seismic Hazard Assessment*
- **Hydro Resolutions** – in-situ hydraulic testing

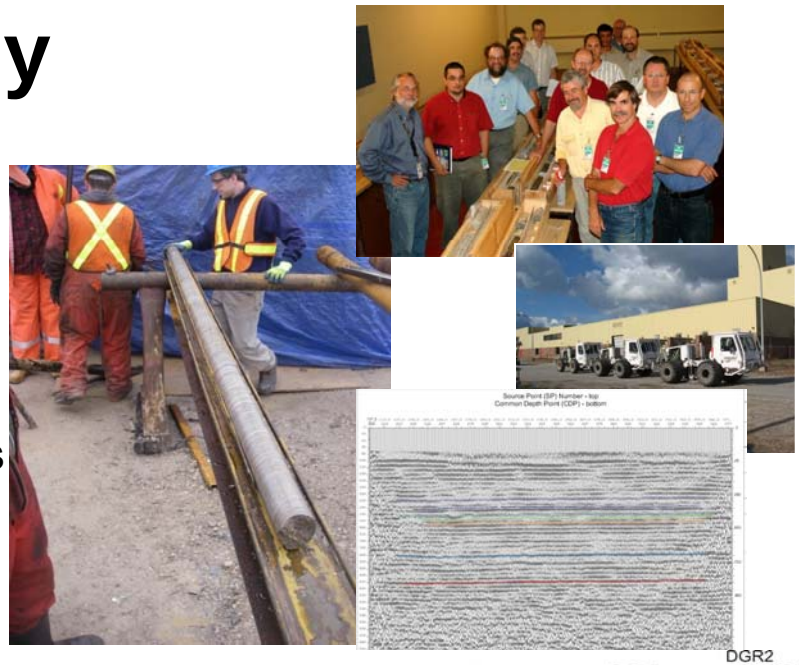
Canadian and International Universities
- **University of Toronto** – *glacial systems modelling*
- ***Queen's University*** - *Geomechanical stability of underground openings, EDZ evolution*
- **University of Waterloo** – *hydrogeological modelling, geology, hydrogeochemistry*
- **University of Ottawa** – *groundwater and porewater chemistry, porewater extraction techniques*
- **University of New Brunswick** – *diffusion testing and method development, hydrogeochemistry*
- **University of Alberta** - *geomechanics*
- **University of Bern** – *groundwater and porewater geochemistry, porewater extraction techniques*
- **University of Washington** – *glacial erosion*
- **Pennsylvania State University** – *cap rock integrity*
- **Monash University** – *outcrop fracture mapping*

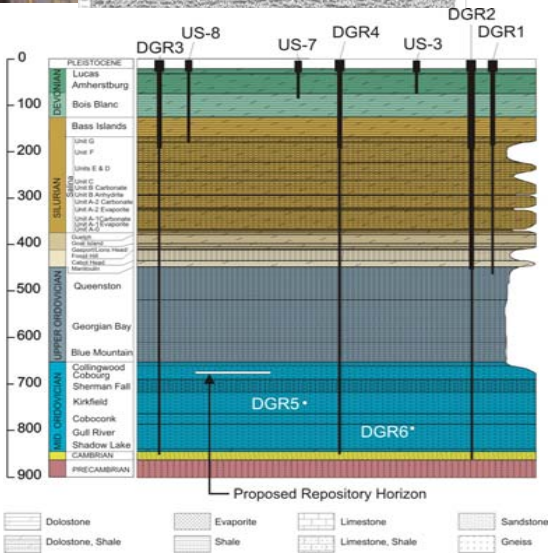
Site Characterization: Field Activities

- Multi-phase site program (2006-2011)
- Six deep cored boreholes (4.7 km; 4 vertical/2 inclined)
- 2-dimensional seismic imaging survey (20 km)
- Installation of micro-seismic (M≈1) monitoring system
- Borehole testing: geophysics/ hydraulic (80+)/geochemical
- 1000+ rock core samples
- Borehole multi-level instrumentation

Geology - Stratigraphy

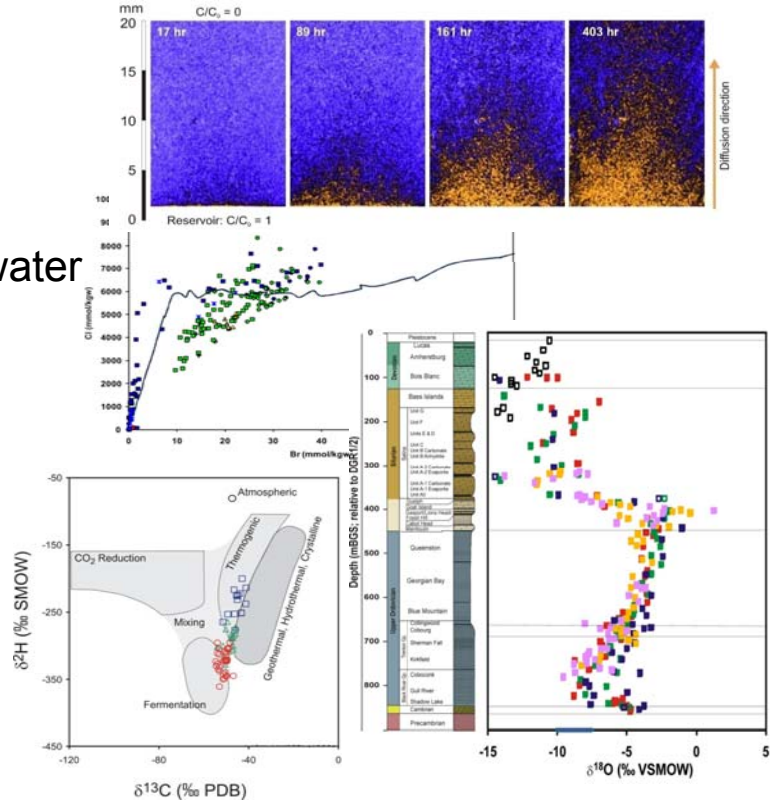
- Predictable Sedimentary Sequence
  - Deep borehole drilling/coring/geophysics
  - 2-D Seismic reflection survey
  - Review historic oil/gas well records
- Bruce Nuclear Site - Stratigraphy
  - Sedimentary sequence 840 m/34 formations
  - Age - Devonian to Cambrian
  - Consistent thickness and orientation
  - Laterally extensive/near-horizontally bedded
- Barrier Rock Integrity - Longevity
  - No evidence fault displacement
  - No evidence carbonate reservoirs
  - Favourable properties (very low K, n, D_e)
  - Site-specific natural analogues - stable
  - Cap rock integrity study – long-term preservation
    - lack of hydraulic fracturing
    - high clay content (self-sealing)
    - absence of hydrocarbon accumulation
    - formation underpressured zones
    - comparison to analogues in Michigan and Appalachian basins





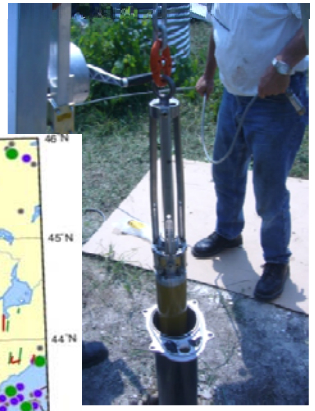
Hydrogeology - Characteristics

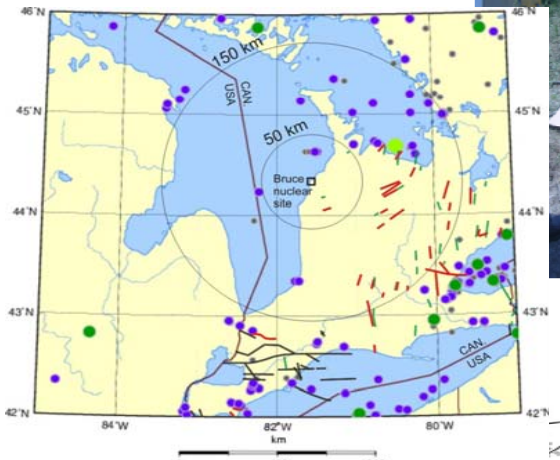
- Groundwater Systems:
  - Shallow (0-170 m) - Aquifer (fresh-brackish)
  - Transition (170-470 m) - Aquitard (brackish-saline)
  - Deep (470-840 m) - Aquiclude (saline)
- Deep Groundwater System:
  - Low rock mass K, low n, Low D_e
  - Saline ~8+ times seawater (TDS > 225 gm/L)
  - Geochemically reducing
  - Porewater signature - ancient evaporated seawater
  - Extremely long groundwater residence times
  - No evidence of glacial recharge
- Site-specific Natural Analogues
  - Anomalous formation pressures – low K
  - Environmental tracer distributions (Cl, ^{18}O)
  - Methane (Biogenic –Thermogenic)
  - Helium in-growth (260 Ma)

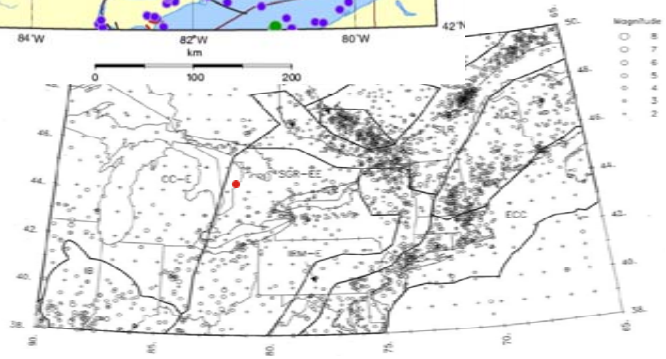


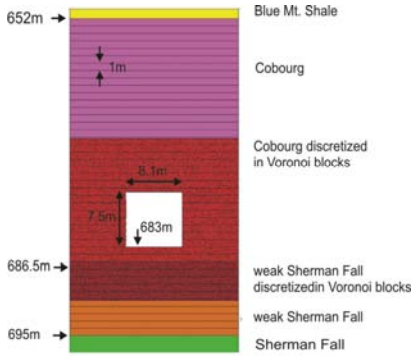
Seismicity

- Tectonically Stable Interior of North America
- Historical Seismic Record (180 yrs) < M5
- Neotectonics
  - No evidence of post-glacial tectonic activity
- Seismic Monitoring
  - Micro-seismic network commissioned 2007
    - M1 events within 50 km
  - Canadian Hazard Information Service
    - Data processing and reporting
  - No seismogenic features near DGR footprint
- Seismic Hazard and Analyses (Postclosure)
  - SSHAC Level II Assessment
  - Return period beyond NBCC requirement (i.e., to 1 Ma)
  - Comprehensive assessment shaft seals/lateral openings
  - No affect on barrier formation integrity – passively safe
  - No affect on seal performance/EDZ extension



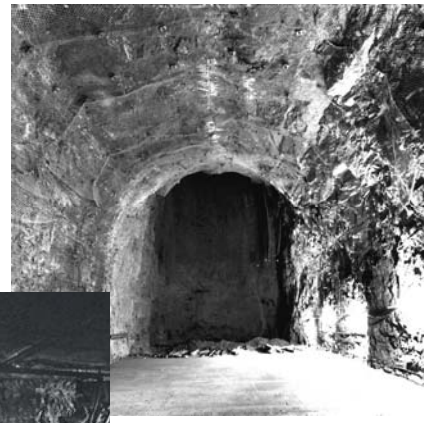


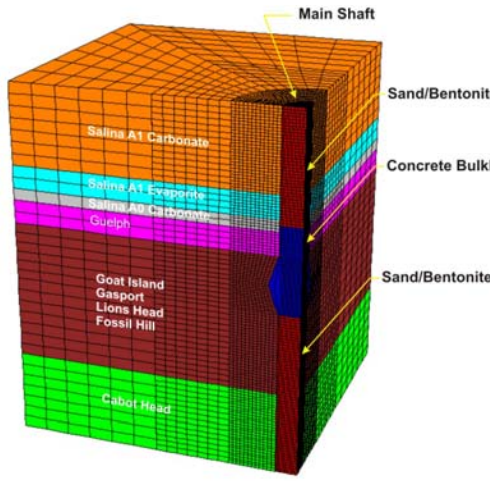


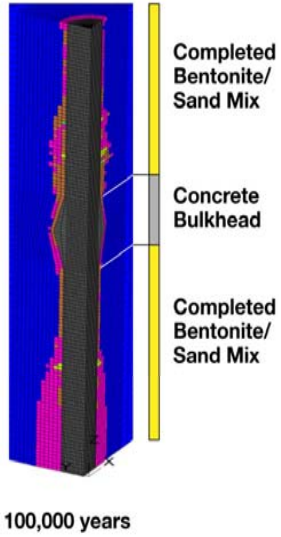


Geomechanics

- Precedent Construction Experience
- Site Characteristics – Repository
  - High RQD/Very good condition
  - Cobourg Formation (lateral development)
    - Competent rock mass
    - Massive/sparsely fractured
    - High strength (UCS ~113 MPa)
  - Moderate in-situ stress
    - No borehole breakout/core disking
- Long-term Stability/Performance (postclosure)
  - Lateral Openings/Sealed Shaft
    - Long-term strength degradation
    - Glacial/seismic loading
    - Gas generation
  - Enclosing barrier integrity unaffected
  - Excavation Damage Zone limited extent

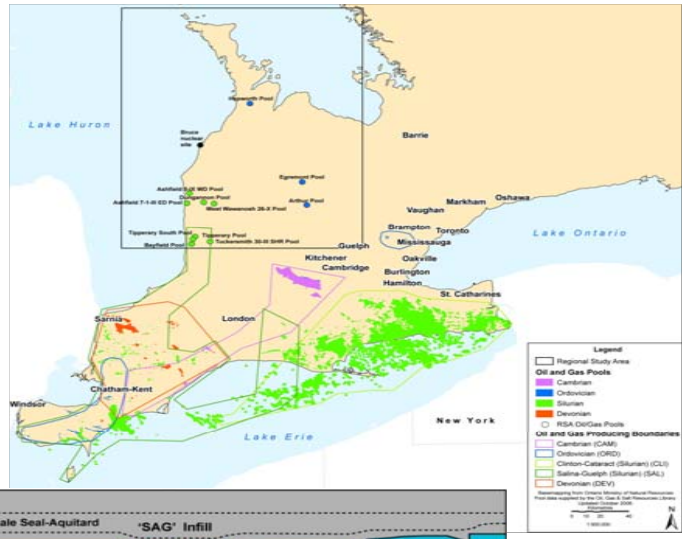


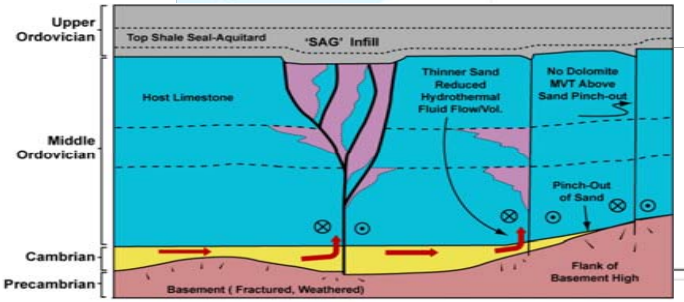


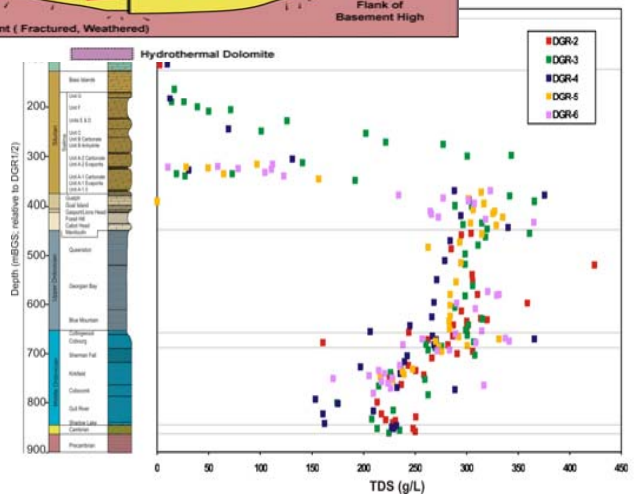


Natural Resources

- No evidence of base metal occurrence
- Salt formations absent in sequence
- Commercial hydrocarbon accumulations - low
  - Historical exploration – beyond 40 km
  - No carbonate reservoir structure
  - Trace occurrence in low K rock mass
- Shale gas potential – low
  - Average Total Organic Carbon <1%
  - Low thermal maturity (oil window)
  - Absence natural gas
  - Absence natural hydraulic fracturing
- Potable groundwater - shallow
  - Below 170 m brackish to saline
  - Low rock mass permeabilities
  - Discourage deep drilling

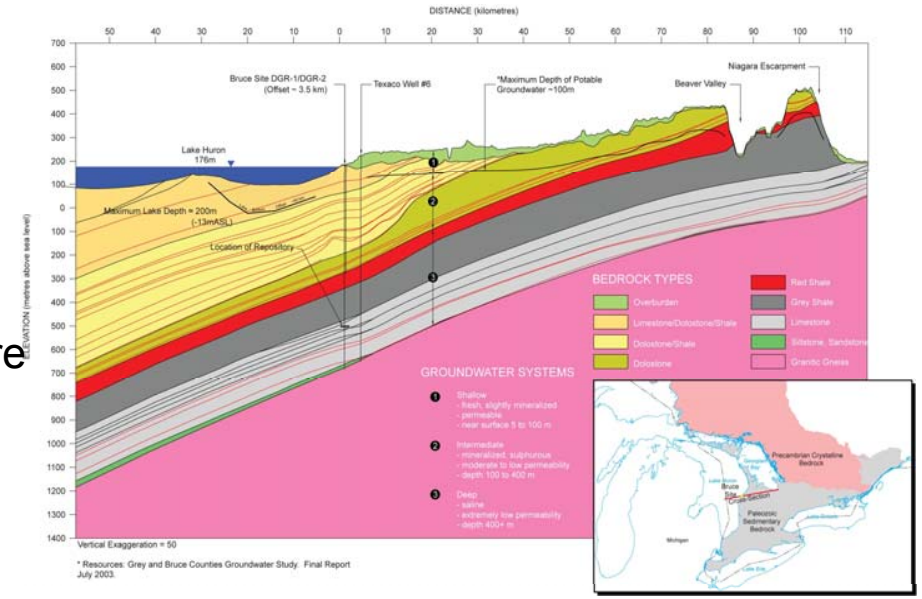






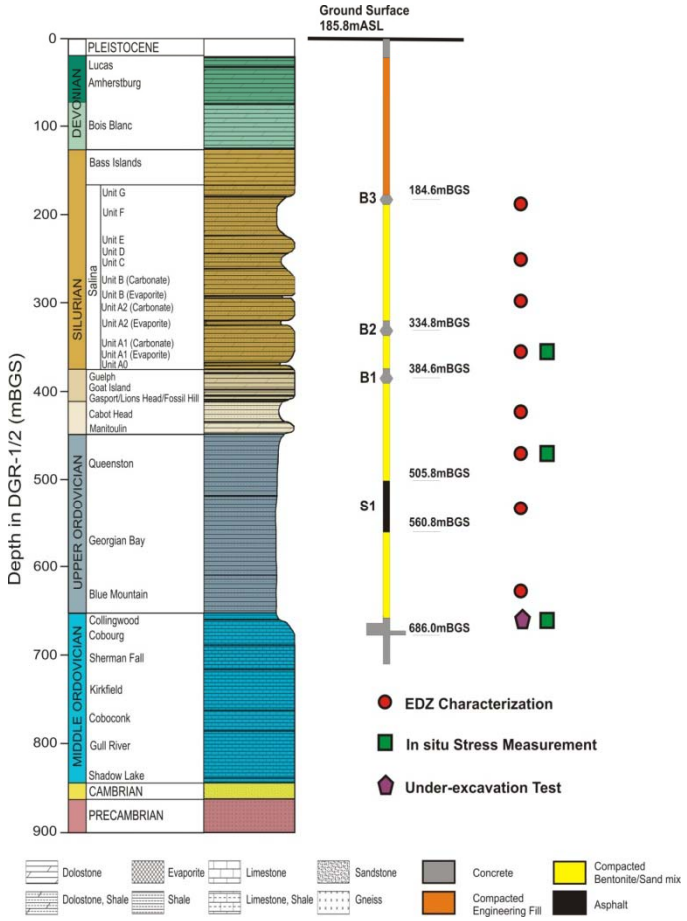
Ground and Surface Waters Protected

- Bedrock Stratigraphy/Hydrostratigraphy
  - Laterally extensive/traceable/thick
  - Near-horizontally bedded - "blanketing"
  - Host/Enclosing formations – Aquiclude
    - Cobourg (27 m)/Cap Rock (200 m)
    - Very low formation scale permeability
  - Overlying Aquitard System (270 m)
  - No evidence transmissive vertical structure
- Site-specific Natural Analogues
  - Resilient to glacial/seismic perturbation
  - Formations contain connate porewaters
  - Environmental tracers/Isotopes
    - Geologically ancient groundwater system
    - Diffusion dominant transport regime
    - Not in communication with surface
    - Long-lived barrier formation properties (10s to 100s Ma)



Geoscientific Verification Plan

- To confirm sub-surface geologic and geotechnical conditions for DGR construction/development
- To support engineering decisions and DGR design
- To support DGR Safety Case and future operating licence application
- Key work program areas:
  - Geologic characterization
  - EDZ characterization
  - Excavation response
  - In-situ stress
  - Chemical/Microbiologic characterization
  - Engineered sealing materials



Conclusions

- **Assessment Geologic Suitability: Safe and Stable for DGR Implementation**
  - The Bruce nuclear site is underlain by multiple, thick, near-horizontally bedded, laterally extensive limestone and shale bedrock formations that possess very low permeabilities
  - The DGR is positioned at a depth of 680 m in a deep seated ancient saline groundwater system that has remained diffusion dominant and stable on geologic time frames. This deep groundwater system has remained isolated from surface waters
  - Future evolution of site is passively safe as bedrock barrier formation function is unaffected by future events (i.e., seismicity; glaciations)
  - Natural resource potential is low – intrusion potential minimized
  - The DGR design applies natural site attributes to isolate and protect ground and surface water resources – materially no impact
  - Geologic attributes are consistent with sites sought by modern international radioactive waste management programs (e.g., France; Switzerland)
  - Geoscientific conditions will be verified during DGR construction