Annex B:
Shale Resources Compendium

Energy and Mines Ministers' Conference
Yellowknife, Northwest Territories
August 2013

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Aussi disponible en français :

Annexe B : Recueil des projets sur les ressources de schiste

This document is the annex B of the report:

Responsible Shale Development – Enhancing the Knowledge Base on Shale oil and Gas in Canada

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A) Policy and Regulatory Developments

BRITISH COLUMBIA	
Initiative Title	***British Columbia Oil and Gas Activities Act (OGAA)***
Initiative goal	*The Oil and Gas Activities Act (OGAA)* modernized and enhanced the regulation of oil and gas activities in British Columbia by strengthening the regulation of the industry through the introduction of new consultation requirements, a new permitting system for activities, and a modernized compliance and enforcement system which includes the introduction of administrative monetary penalties and significantly higher penalties for offences.
Initiative description Timeline: 2002 – 2010	The *OGAA* was brought into force on October 4, 2010. *OGAA* replaced the *Oil and Gas Commission Act*, the *Pipeline Act* and regulatory provisions of the *Petroleum Gas Act*. The British Columbia Oil and Gas Commission (OGC) regulates oil and gas activities in the Province under OGAA. The enhanced regulation in *OGAA* is balanced by the creation of a new appeal tribunal to hear challenges to regulatory decisions of the OGC, and changes to the OGC's authority to approve and encourage innovations in technology and practices. Objectives of *OGAA* include safe and responsible development of oil and gas resources in British Columbia and: • **Environmental responsibility** – through requirements to protect and manage environmental values. New compliance and enforcement tools encourage compliance with these environmental requirements plus all other requirements under *OGAA*. • **Social responsibility** – through the requirements to consult and notify land owners and other affected parties of proposed activities before a permit application is submitted to the OGC. A review and appeal process is provided to help ensure consistent and fair decision-making by the OGC. Requirements to adhere to standard industry practices help ensure the safety of the public and practitioners. Provides an expanded and modern suite of compliance and enforcement tools that can be effectively used against a wider range of non-compliant situations. • **Thriving and innovative industry** – through a single-window approach by the OGC. Provides an attractive oil and gas sector that is competitive with other jurisdictions, provides clear and consistent regulatory requirements that apply to all operators and practitioners conducting any oil and gas activity in B.C, and provides a streamlined

	and simplified regulatory framework. There is flexibility to quickly and easily accommodate innovation, new investments, developments, technologies and/or approaches. Extensive consultations began in 2002 through the Oil and Gas Regulatory Improvement Initiative (OGRII), which involved communities, local governments, First Nations, companies, landowners, environmental organizations and industry associations. The OGC had an entire team working on the implementation of *OGAA*. It held an *OGAA* Practitioner's Conference, carried out extensive training for both industry and staff and had a dedicated website.
Summary of key findings	The OGAA Training and Support Program contained multiple tools to provide people with on-going support. The tools included the following: **A. OGAA Guidance Manuals** • Helpful information and details on policy, procedures, interpretations and administration—available on the OGC website. **B. OGAA Resource Kit** • Regulations, presentations and notes available on the OGAA website. • OGAA Webinars - Short (1-2 hour) presentations on OGAA updates, interpretations and advanced topics delivered electronically to the participant's work place. Webinars delivered 6-12 months after the initial OGAA implementation. **C. Advanced Topics/Workshops** • Skills training developed and delivered on a variety of topics such as operating procedures (e.g., best practices), computer applications and OGAA implementation workshops. These training sessions were determined by individual organizations or sectors (e.g., OGC, industry associations). D. **OGAA Website** • Training materials (presentations and notes, OGAA Primer, additional materials); Frequently asked questions; and Link to OGAA and Regulations.
Partners	Government of British Columbia - Ministry of Energy, Mines and Natural Gas; British Columbia Oil and Gas Commission (OGC)
Key contact	British Columbia Oil and Gas Commission

BRITISH COLUMBIA	
Initiative Title	**Area-based Analysis: Overview**
Initiative goal	The Area-based Analysis approach, developed by the British Columbia Oil and Gas Commission, evaluates oil and gas development opportunities by analyzing existing land-use, regulatory requirements, government policy and direction. The analysis then builds a landscape-level picture of the impact that oil and gas activity and other activities have on a particular region and the management tools available to the Commission.
Initiative description Timeline: Announced in 2013	An analysis of each unconventional gas basin area will be summarized in area-specific reports produced by the British Columbia Oil and Gas Commission. These reports will be updated periodically to reflect new information including updates to relevant government policy and legislation and recent development activities, and to report on outcomes and provide guidance during operational planning and permitting to avoid or minimize conflicts with identified values. Area-based analyses integrate direction from statutes and regulations, relevant elements of land-use planning, and environmental and social values into a coherent and clarified framework for managing oil and gas development. Area-based analyses will: • Provide a consistent rationale and process for identifying environmental and social values. • Clarify objectives as set out in government policy and statutes. • Provide an analysis of existing development and the opportunity for future oil and gas activity. • Provide a simplified and transparent framework to assess and manage oil and gas development impacts on environmental and social values. The British Columbia Oil and Gas Commission has identified the following unconventional basins in northeast British Columbia as key areas for area-based analyses: Liard, Horn River, Montney, and Cordova.
Summary of key findings	The initial natural gas basin undergoing area-based analysis is the Liard. The Montney, Cordova and Horn River basins will follow and potentially the rest of northeast British Columbia A series of public reports including Land-use Reports, Area-based Analyses and others will be produced for each identified area.
Partners	British Columbia Oil and Gas Commission
Key contact	British Columbia Oil and Gas Commission

ALBERTA	
Project/Study Title	***Directive 059*** **and FracFocus.ca**
Project/Study Goal	Amendments to *Directive 059*: *Well Drilling and Completion Data Filing Requirements* in support of the disclosure of hydraulic fracturing fluid information to increase transparency and public information through FracFocus.ca.
Project description Timeline:	Regulatory Requirement Completed December 2012
Summary of key findings	The changes to *Directive 059* include the following: • new requirements for licensees to electronically report fracture fluid data, including service provider, fracture scenario, carrier fluid type, proppant type, and fracturing fluid chemical additive and ingredient information for wells that have been fractured after December 31, 2012. • electronically report water source data, including source location, source type, diversion permit information, and volume for all water used in hydraulic fracturing operations with water quality information required for groundwater sources. • reporting fracture fluid and water source data in daily records of operations. • protocols to provide limited protection of proprietary information associated with hydraulic fracturing fluids. Alberta content on the FracFocus website was included in December 2012.
Partners	New West Partnership; Collaboration and Information Sharing, Industry Water Use and Hydraulic Fracture Technology Project involving Alberta, British Columbia, and Saskatchewan.
Key contact (s)	Alberta Energy Regulator

ALBERTA	
Project/Study Title	**Unconventional Gas Regulatory Framework—Jurisdictional Review**
Project/Study Goal	The objective of the Jurisdictional Review was to learn how other jurisdictions were regulating unconventional gas development, what issues were encountered, and how these were managed within the regulatory framework. The report summarizes the findings of the Jurisdictional Review Task Team and identifies opportunities to be considered for Alberta's unconventional gas regulatory framework.
Project description Timeline:	Multi-jurisdictional regulatory review Completed January 28, 2011
Summary of key findings	The report identified a number of regulatory change opportunities in the areas of: • Resource Appraisal and Reserves • Reservoir Development • Drilling and Completion-Water Management • Landowner and Public Concerns • Environment • Regulatory Processes • Information and Dissemination
Partners	The following jurisdictions submitted completed written surveys: • Michigan Department of Natural Resources and Environment—Office of Geological Survey • Louisiana Department of Natural Resources—Office of Conservation • Saskatchewan Ministry of Energy and Resources The following jurisdictions provided input through detailed telephone interviews: • British Columbia Oil and Gas Commission • Pennsylvania Department of Environmental Protection-Bureau of Oil and Gas Management • Oklahoma Corporation Commission • Railroad Commission of Texas
Key contact (s)	Alberta Energy Regulator

ALBERTA	
Project/Study Title	***Directive 083 Hydraulic Fracturing – Subsurface Integrity***
Project/Study Goal	Key Objectives of the Directive • Prevent the loss of well integrity at a subject well. • Reduce the likelihood of interwellbore communication between a subject well and an offset well. • Manage well control at an offset well in the event of interwellbore communication with a subject well. • Prevent adverse effects to nonsaline aquifers • Prevent impacts to water wells. • Prevent surface impacts.
Project description Timeline:	Regulatory requirements Released May 21, 2013 effective August 23, 2013
Summary of key findings	Maintaining Well Integrity The new directive requires licensees to demonstrate that operational risks have been considered in the selection and design of the wellbore construction and to monitor and test to ensure that well integrity is maintained. Interwellbore Communication To address the risks associated with interwellbore communication, the directive requires licensees to carry out a risk assessment and prepare a well control plan. Protection of nonsaline Aquifers The directive requires licensees to carry out a risk assessment and risk planning. Fracturing Operations at Shallow Depths Under the directive, all licensees carrying out hydraulic fracturing operations in this zone must: •Conduct a risk assessment. •Observe prescribed setbacks for water wells and top of bedrock. • Use environmentally friendly chemical additives or fluid compositions above the base of groundwater protection.
Partners	N/A

Key contact (s)	Alberta Energy Regulator

ALBERTA	
Initiative Title	**The Unconventional Regulatory Framework**
Initiative goal	Establish a new approach to regulating unconventional resources, such as shale oil and shale gas
Initiative description Timeline: Still under development; discussion paper released December 2012	Alberta has a long history of regulating oil and gas development. The discussion paper continues that strong record by describing a proposed regulatory approach that is innovative and progressive. The technology used to develop unconventional resources is not new in Alberta; however, the scale of the developments has the potential to be much larger than experienced in the past. To address the associated challenges with large-scale developments, the ERCB has suggested a new regulatory approach that includes moving from well-by-well regulation to regulation focused on development within a defined area. This play-focused regulation would be performance-based to achieve specific outcomes in public safety, water protection, air quality, waste management, surface impacts, resource conservation, and orderly development. Therefore, a new approach will be based on two basic principles: • Risk-based regulation – requires regulatory responses that are proportional to the level of risk posed by energy development. • Play-focused regulation – requires regulatory solutions that apply to an entire "play" and are designed to achieve specific environmental, economic, and social outcomes.
Summary of key findings	Process still underway
Partners	Alberta Energy Regulator
Key contact	Brad Hubbard (brad.hubbard@aer.ca; 403-297-8502); Karen Blank (karen.blank@aer.ca; 403-297-6964

ONTARIO	
Initiative Title	**Review of Ontario's Policy Framework respecting the Use of High-volume Hydraulic Fracture Treatment**
Initiative goal	To review Ontario's policy framework with regard to the use of high-volume hydraulic fracturing treatment. The review will include a jurisdictional scan and the analysis of existing scientific information, legislation, regulations, and policies related to hydraulic fracturing.
Initiative description Timeline: January 2013 – December 2014 **(estimated)**	Currently shale gas or shale oil is not being extracted anywhere in Ontario, nor are any proposals before the Ministry of Natural Resources requesting approval to explore for shale resources or for the use of high-volume hydraulic fracturing. The potential for shale gas in bedrock of southern Ontario is being assessed by the Ministry of Northern Development and Mines' Ontario Geological Survey. A key question for the review is to evaluate whether there are any gaps in Ontario's current policy framework that need to be addressed?
Summary of key findings	Review is still underway
Partners	Ontario Ministry of Natural Resources; Ontario Ministry of the Environment; Input from other Ontario government ministries.
Key contact	Ray Pichette, Director, Natural Heritage Lands and Protected Spaces Branch, Ontario Ministry of Natural Resources, 300 Water Street Peterborough, Ontario K9J 8M5 (705) 755-1241; ray.pichette@ontario.ca Sharon Bailey, Director – Land and Water Policy Branch, Ontario Ministry of Environment, 135 St Clair Ave W, Toronto ON M4V1P5 (416) 314-7020; sharon.bailey@ontario.ca

QUÉBEC	
Initiative Title	**Strategic Environmental Assessment (SEA) Committee on Shale Gas**
Initiative goal	To define an SEA implementation plan and carry out related work and studies. A Summary Report of related studies and the Committee's expert observations are to be used for establishing a basis for an extensive consultation by the Bureau d'audience publiques (BAPE)
Initiative description Timeline: Report to be submitted by November 29, 2013	On March 8, 2011 the Minister of Sustainable Development, Environment, and Parks released a BAPE report on the sustainable development of the shale gas industry in Québec, which included a recommendation to conduct an (SEA) by setting up an expert committee to carry out that assessment. The Committee is charged with conducting the SEA is composed of experts drawn from municipal, governmental, private and university circles. There are also two experts from civil society and a third from an environmental organization. The general mandate of the Committee is to produce: • An economic assessment of the socioeconomic benefits of exploiting the shale gas resource, and of the conditions that would maximize revenue for the government. • An assessment of the environmental risks and impacts, the factors influencing social acceptability, and appropriate mitigation measures. • Guidelines and parameters for a regulatory framework for both the environmental assessment of gas exploration and exploitation projects and the execution of such projects, applicable to the St. Lawrence Valley and if possible elsewhere in Québec. • An assessment of the need for scientific observatories that would acquire knowledge on a continuous basis and ensure that regulations are kept up to date. In performing its mandate, and within the established budgets and timelines, the committee may also consider any other relevant questions pertaining to the exploration and exploitation of oil and gas resources, as well as their repercussions.
Summary of key findings	Committee is still underway
Partners	Ministry of Sustainable Development, Environment, and Parks; Bureau d'audience publiques (BAPE)

NEW BRUNSWICK	
Initiative Title	**Responsible Environmental Management of Oil and Gas Activities in New Brunswick: New Rules for Industry**
Initiative goal	The new rules, which build on existing regulations, were released in order to support New Brunswick's on-going management of oil and gas activities to ensure the Province continues to have the tools needed to guide oil and gas exploration in an environmentally responsible manner.
Initiative description Timeline: Released February 2013	The rules are to ensure that regulators, industry and New Brunswickers have access to common set of accurate information about oil and gas activities in New Brunswick such as through prescribed minimum notification radius for seismic testing and disclosure of all proposed and actual contents of all fluids used in the hydraulic fracturing process For the most part, the rules will be implemented as conditions to Approvals and Certificates of Determination issued under existing legislation including the *Oil and Natural Gas Act*, *Clean Environment Act*, the *Clean Air Act* and the *Clean Water Act*. The rules were informed by several preceding steps: • A public discussion paper released in May 2012 outlined a number of recommendations based on advice from a broad cross-section of participants. • The Province asked Dr. Louis Lapierre to chair a panel to obtain feedback on the discussion document, including through nine-public meetings on shale gas development. His October 2012 report, The Path Forward, contained a series of recommendations. • In September 2012, the New Brunswick Chief Medical Officer issued a report containing recommendations concerning shale gas development from a public health perspective, which include taking into account historical experience from other jurisdictions. The rules informed a subsequent New Brunswick Oil and Natural Gas Blueprint that was released in May 2013.
Summary of key findings	Requirements cover a broad range of issues at all stages from exploration to well abandonment, e.g., enhanced certification and training requirements, enhanced monitoring and management planning for water resources, air quality monitoring, an orphan well and environmental contingency fund, public disclosure of project information, and ongoing need to gather scientific information.
Partners	New Brunswick Department of Energy and Mines
Key contact (s)	New Brunswick Department of Energy and Mines

NOVA SCOTIA	
Initiative Title	**Environmental Review of Hydraulic Fracturing in Oil and Gas Operations**
Initiative goal	To review the potential environmental impacts of hydraulic fracturing in onshore oil and gas activities.
Initiative description Timeline: Ongoing into 2014	The review is involves three main areas of focus, including: • A public comment period to ensure the review considered the main areas of citizen concern; • An assessment of the scientific knowledge related to the potential environmental impacts of hydraulic fracturing, in particular, issues related to water; and • A jurisdictional review to understand how other provinces and states regulate unconventional resource development with regard to hydraulic fracturing and identify current regulatory best practices for activities related to hydraulic fracturing. Since 2011 the Review Team, comprised of senior technical and policy staff from both departments, have been working collaboratively through this process. Results from their work to date have been posted online at www.gov.ns.ca/nse/pollutionprevention/consultation.hydraulic.fracturing.asp. The review is primarily designed around issues related to water, since many of the potential impacts from hydraulic fracturing are ultimately associated with water. These issues include: • **Effects on Groundwater**: short and long-term potential risks to groundwater and water wells, including the need for baseline groundwater monitoring, water well survey data, etc. • **Use of and effects on surface water**: water acquisition for hydraulic fracturing operations and the impact to surface water, impacts to aquatic ecosystems, impacts to other water users, etc. • **Impacts on land and potential soil contamination**: impacts of storage and handling of hydraulic fracturing additives and petroleum products on soil, considering site development, proximity to surface and groundwater, transportation and disposal of chemicals, etc. • **Additives in and disclosure of hydraulic fracturing fluids**: mixing of additives, life cycle in the environment, storage and handling, and requirements for public disclosure • **Waste management, including surface ponds of produced water**: waste management technologies for water treatment, brine storage ponds, deep well injection, chemistry of natural formation and waste

	waters, drill fluid and mud treatment and disposal, etc. • **Site restoration**: well decommissioning, removal of infrastructure, soil remediation, etc. • **Submission requirements for hydraulic fracturing design**: chemicals used and engineered design • **Demonstration of operator financial security & insurance prior to drilling**: assess financial requirements are required to have prior to drill to ensure ability to address any associated risks There are no current applications to conduct hydraulic fracturing in Nova Scotia, and the province has committed that no hydraulic fracturing operations will be approved during the review period.
Summary of key findings	Thus far, the province received almost 280 written submissions during the public comment period. Many issues raised fell within the planned project scope as they were related to environmental impacts (i.e. ground and surface water, waste management, air quality, etc.). Two areas of focus were added to the review: the disclosure of additives in fracturing fluids; and submission requirements for fracture design prior to activity. Comments were received from private citizens, environmental groups, first nations, health and social interest groups, as well as petroleum organizations.
Partners	Nova Scotia Department of Energy Nova Scotia Department of the Environment

B) Understanding and Assessing the Resource Base

FEDERAL	
Project/Study Title	**Methodology development for assessing shale gas resources in Canadian shale basins**
Project/Study Goal	The project will focus on developing a new resource assessment methodology suitable for Canadian shale basins that can be performed independently by Canadian governments and is publicly available.
Project description Timeline: April 1, 2012 – March 31, 2016	The methodology will provide a tool for a comprehensive, consistent, standardized, and easily updatable resource assessment of shale and other types of unconventional resources for Canada. It includes four parts: 1) a volumetric approach for the in place resource estimation, 2) a productivity-based approach for estimating the recoverable resource, 3) a cross validation mechanism validating and updating the volumetric estimates using available production data or analog data, and 4) a statistical method for comparing the geological characteristics between analogues.
Summary of key findings	Complete key findings will be disclosed at the project end date (March 31, 2016). Preliminary results might be disclosed prior to this end date. It is anticipated that application of this methodology could provide resource information to support regulatory and exploration needs and help regulators and industry reduce production risk and prioritize drilling targets, thus also reducing environmental impacts of energy production, conversion, distribution and use. The project will be located in Calgary.
Partners	The project team is led by research scientists from Natural Resources Canada (NRCan) from the Geological Survey of Canada. Non-NRCan collaborators include: • National Energy Board • National Research Council
Key contact	Zhuoheng Chen, Geological Survey of Canada, NRCan, 403 292 7115, zchen@nrcan.gc.ca

FEDERAL	
Project/Study Title	**Developing Methodologies for, and Addressing Key Knowledge Gaps in Unconventional Shale Systems**
Project/Study Goal	The project intends to achieve an improved methodology which better defines and characterizes organic matter within unconventional petroleum rocks.
Project description Timeline: April 1, 2012 – March 31, 2016	The project involves resource assessments and characterization studies of Canadian unconventional oil/gas systems where there is a significant knowledge gap on the role of organic matter in the development of porous space, conduct of the hydrocarbon through the formations, permeability, thermal maturity and the generation potential of hydrocarbons. The questions addressed by the study are the following: • Geochemical Improvement of the functionally defined parameters obtained from Rock-Eval Analyses and organic petrology in unconventional systems. • Understanding/characterizing (modeling) the evolution of pore spaces within organic matter during thermal maturation. • Improvement of thermal maturity indicators as the main exploratory and assessment tool for unconventional petroleum systems. • Quantitative assessment of multi-phase hydrocarbons recourses by an innovative measurement of various hydrocarbon fractions within the rock, which leads to improved measurement of gas and oil in place for unconventional systems. • Understanding and characterizing the interaction between mineral matrix and organic matter and its influence on hydrocarbon production within unconventional petroleum rock formations. The Project will be located in Calgary.
Summary of key findings	Complete key findings will be disclosed at the project end date (March 31, 2016). Preliminary results might be disclosed prior to this end date. The results of this project will lead to organic geochemical and petrological methodologies and generate knowledge, which helps improved assessment of the resource nationwide and to understand the short-term and long-term behaviours of the unconventional systems during production for both operators and regulators. The improved techniques and the knowledge generated by this project will ultimately improve our understanding of the unconventional resources in Canada and increase the efficiency of technology involving exploration, development, and sustainable production

	of these resources.
Partners	The project team is led by research scientists from Natural Resources Canada (NRCan) from the Geological Survey of Canada
Key contact	Hamed Sanei, NRCan/Geological Survey of Canada-Calgary, 403-292-7045; hsanei@nrcan.gc.ca

FEDERAL	
Project/Study Title	**Seismic tool for assessing baseline near-surface geoscience knowledge for petroleum exploration and development (includes second report).**
Project/Study Goal	Using seismic shothole drillers' log records, this project was designed to provide public baseline near-surface geoscience information that supports the identification of granular aggregate resources considered critical to infrastructure development (e.g., roads, pipelines, well-pads) including unconsolidated frac sand sources, and the assessment and understanding of geohazards (landslides, ground ice occurrences, permafrost thickness, artesian aquifers).
Project description Timeline: April 2008 – March 2011	This project was the first to demonstrate the broad application and utility of seismic shothole drillers' log records (something Industry had collected, but never utilized) to the understanding of near-surface geology, including the territorial-scale reconstruction and interpretation of: (1) potential granular aggregate and frac sand resources, (2) geohazards (ice, water, gas below surface), (3) drift and till thicknesses, (4) till facies, (5) permafrost and ground ice, (6) muskeg thickness, and (7) bedrock outcrop and subcrop localities. The project digitally and spatially rendered all available seismic shothole drillers' log records housed in Industry archives from continental Northwest Territories and Yukon. Geoscience information extracted and interpreted from other published maps, reports and databases were synthesized with the shothole database and GIS into integrative thematic publications relevant to different aspects of petroleum exploration and development, including infrastructure, hazards, and environmental assessment. The project was based in Calgary, Alberta
Summary of key findings	Results included: • The project digitally rendered and made publically available 344 00 records of formerly unutilized baseline geoscience data in areas of active petroleum exploration, including shale gas operations in southern NWT, and Canol Formation shale oil exploration in the Norman Wells region • The thematic database and GIS publications produced from this study have established significant digital reference tools that are being used to guide and improve the efficiency and cost effectiveness of field investigations and environmental assessments, and the environmental sustainability of northern pipelines and related infrastructure design, assessment, and development.

	• The reconstruction of surface and subsurface potential granular aggregate resources is considered the most immediate and significant outcome of this project as it identifies over a billion dollars worth of a key limiting resource in areas of new and existing petroleum exploration, and community/territorial (e.g., roads) infrastructure development • The granular aggregate resource reconstruction identifies potential unconsolidated frac sand sources, which can be targeted for additional exploration and assessment
Partners	Led by the Geological Survey of Canada (GSC), involving two GSC-based GIS technicians and 30+ students hired as database and GIS technicians, and in collaboration with: • 23 companies provided access to the extent of their archival holdings • 99 companies, successors, or data stewards authorized release of joint-venture and partnered data • Northwest Territories Geoscience Office • University of Calgary
Key contact	Rod Smith, NRCan/Geological Survey of Canada-Calgary, 403-292-7132; rodsmith@nrcan.gc.ca

BRITISH COLUMBIA	
Project/Study Title	**Montney Formation Play Atlas Northeast British Columbia**
Project/Study Goal	The Montney Formation Play Atlas was compiled to summarize the results of a regional mapping initiative in support of a collaborative Montney Resource Assessment with the National Energy Board, the British Columbia Ministry of Energy, Mines and Natural Gas and Alberta's Energy Resources Conservation Board.
Project description Timeline: October 2011 - October 2012	The series of maps that comprise this report were derived from non-confidential well and core data to aid in the delineation and distribution of regional unconventional play parameters for the Montney Formation within northeast British Columbia. The Montney Formation Play Atlas was the British Columbia Oil and Gas Commission's major contribution to the multi-agency Montney Resource Assessment that is due to be publically released summer 2013.
Summary of key findings	**Montney Trend/Activity (4) Maps** •Montney Unconventional Play Trend •Montney Fields and Pools •Montney Activity 2011-2012 •Lower Montney Turbidite Trends **Cross Sections (2)Maps** •Altares to Chinchaga River •Sundown to Dawson Creek **Structure(2) Maps** •Structure to top Montney •TVD Depth to top Montney **Isopachs (4)Maps** •Total Montney •Upper Montney •Lower Montney •Belloy to Debolt **Montney Formation (4)Maps** •Temperature •Pressure •Pressure Gradient •Maximum Frac Stimulation Pressure

	Mineralogy (4)Maps •Percent Quartz •Percent Feldspar •Percent Carbonate •Percent Clay **Gas Analyses (4)Maps** •Percent C3+ •Percent C5+ •Weighted C6+ Content •H2S Fraction **Maturity (1)Map** •Tmax **Gas Liquids (5)Maps** •2011 BC08 C3 & C4 •2011 BC08 C5+ •Q1 2012 BC08 C3 & C4 •Q1 2012 BC08 C5+ •Montney Liquids Trend
Partners	British Columbia Ministry of Energy, Mines and Natural Gas
Key contact	Mark Hayes, Technical Leader Resource Assessment, British Columbia Oil and Gas Commission, 250 419-4431, mark.hayes@bcogc.ca

BRITISH COLUMBIA	
Project/Study Title	**Besa River Formations, Western Liard Basin, British Columbia (NTS 094N): Geochemistry and Regional Correlations**
Project/Study Goal	This project will characterize Besa River Formation shales in outcrop (i.e. rock exposure at the surface) which contains equivalents to the Horn River Formation. This information will outline readily accessible surface analogues to Horn River subsurface shales.
Project description Timeline: April 2010 – March 2011	The study area is located approximately 225 km northwest of Fort Nelson, just south of the British Columbia-YT border, in the western part of the Liard Basin. The study entailed measuring and description of a section of Besa River Formation together with acquisition of samples across 2 m intervals. These were analyzed for organic geochemistry by Rock-Eval pyrolysis, and lithogeochemistry. Gamma ray spectrometry data was acquired every metre via a hand held spectrometer and representative samples were taken for thermal maturation determination by reflective light microscopy. Gamma ray logs and other data were used to create logs that could be used to correlate the unit into similar sections in the subsurface. Questions addressed include: • thickness; • composition; • thermal maturity; • organic and litho geochemistry; • and correlation into the subsurface. The Besa River Formation is divisible into 6 lithostratigraphic units and 285 metres of the formation was measured.
Summary of key findings	• Rock-Eval analysis indicates 2 zones of high organic carbon reaching 6 per cent by weight. • Correlation of gamma ray trace into the subsurface indicates the Besa River Formation contains equivalents to the Muskwa member of the Horn River Formation and the Exshaw Formation.
Partners	This study is part of a collaborative program between the Geological Survey of Canada and the British Columbia Ministry of Energy and Mines, and is under the umbrella of the federal government's Geo-mapping for Energy and Minerals program.
Key contact	Filippo Ferri, Director, Petroleum Geology, British Columbia Ministry of Energy, Mines and Natural Gas, 250-952-0377, fil.ferri@gov.bc.ca

BRITISH COLUMBIA	
Project/Study Title	**Geochemistry and Shale Gas Potential of the Garbutt Formation, Liard Basin, British Columbia (Parts NTS 094N, O; 095B, C)**
Project/Study Goal	This project will characterize Garbutt Formation shales in outcrop (i.e. rock exposure at the surface) which contains organic-rich shales which may have potential as a resource play (i.e. shale gas). These shales will be correlated with similar sequences in the subsurface within the Liard Basin.
Project description Timeline: April 2010 – March 2011	The study area is located approximately 200 kilometers northwest of Fort Nelson, south of the British Columbia-Yukon Territory border, in the western part of the Liard Basin. The study entailed measuring and description of several sections of Garbutt Formation together with acquisition of samples across 2 metre intervals. These were analyzed for organic geochemistry by Rock-Eval pyrolysis, and lithogeochemistry. Gamma ray spectrometry data was acquired every metre via a hand held spectrometer and representative samples were taken for thermal maturation determination by reflective light microscopy. Gamma ray logs and other data were used to create logs that could be used to correlate the unit into similar sections in the subsurface. Questions addressed include: • thickness; • composition; • thermal maturity; • organic and litho geochemistry; • and correlation into the subsurface. Also, 285 metres of the formation was measured.
Summary of key findings	• Deposition below storm wave base in a pro-delta environment. • Rock-Eval analysis indicates an average total organic carbon content of 1.12 wt % with peaks between 1.2 and 1.67%. • Depositional conditions were near the oxic – anoxic boundary.
Partners	This study is part of a collaborative program between the Geological Survey of Canada and the British Columbia Ministry of Energy and Mines, and is under the umbrella of the federal government's Geo-mapping for Energy and Minerals program (GEM).
Key contact	Filippo Ferri, Director, Petroleum Geology, British Columbia Ministry of Energy, Mines and Natural Gas, 250-952-0377, fil.ferri@gov.bc.ca

BRITISH COLUMBIA	
Project/Study Title	**Toad Formation (Montney and Doig equivalent) in the Northwestern Halfway River Map Area, British Columbia (NTS 094B/14)**
Project/Study Goal	This project will characterize Toad Formation shales in outcrop (i.e. rock exposure at the surface) which contains equivalents to organic-rich shales of the Montney and Doig formations. This information will outline readily accessible surface analogues to Montney and Doig subsurface shales.
Project description Timeline: April 2009 – March 2010	The study area is located approximately 125 kilometres northwest of Fort St. John, at the northern end of the Montney unconventional play trend. The study entailed measuring and description of a sections of the Toad Formation together with acquisition of samples across 5 metre intervals. These were analyzed for organic geochemistry by Rock-Eval pyrolysis, and lithogeochemistry. Gamma ray spectrometry data was acquired every metre via a hand held spectrometer and representative samples were taken for thermal maturation determination by reflective light microscopy. Gamma ray logs and other data were used to create logs that could be used to correlate the unit into similar sections in the subsurface. Questions addressed include: • thickness; • composition; • thermal maturity; • organic and litho geochemistry; • and correlation into the subsurface. Also, 630 metres of the Toad Formation was measured.
Summary of key findings	• Deposition through high-density flows (turbidites). • Rock-Eval analysis indicates an average total organic carbon contents of up to 5 weight per cent. • Toad Formation correlates with the Montney and Doig formations.
Partners	This study is part of a collaborative program between the Geological Survey of Canada and the British Columbia Ministry of Energy and Mines, and is under the umbrella of the federal government's Geo-mapping for Energy and Minerals program (GEM).
Key contact	Filippo Ferri, Director, Petroleum Geology, British Columbia Ministry of Energy, Mines and Natural Gas, 250-952-0377, fil.ferri@gov.bc.ca

BRITISH COLUMBIA	
Project/Study Title	**Horn River Basin-Equivalent Strata in Besa River Formation Shale, Northeastern British Columbia (NTS 094K/15)**
Project/Study Goal	This report summarizes preliminary results from the 2011 field season, part of an ongoing project examining surface exposures of Horn River basin–equivalent strata within the Besa River Formation in northeastern British Columbia.
Project description Timeline: June 2011 – August 2011	The main objectives of this report is to delineate units in outcrop that are equivalent to shale gas–producing horizons in the subsurface, thereby providing potential reference sections for understanding the geological setting of the strata in the Horn River basin. Questions addressed include: • What are the analytical results of Gamma-ray Spectometry? • What are the analytical results of Rock-Eval and Thermal Maturity? Methodology included field sampling, analysis and reporting. Approximately 310 metres of rocks belonging to the Besa River Formation were measured and described in two sections along a small, west-facing gully located approximately 12 kilometres northwest of Stone Mountain. Field work occurred near Fort Nelson, British Columbia - Northeast British Columbia and office work took place in Victoria, British Columbia.
Summary of key findings	• The 2011 Besa River Formation section in the Stone Mountain area is broadly similar to that measured in the Caribou Ranges during the 2010 field season. • Peak natural gamma-ray levels (and uranium contents) of the 2011 section are half the levels seen in the 2010 section. • Correlation of the surface gamma-ray log with the subsurface section to the southeast and northeast indicates the presence of the Evie, Muskwa and Exshaw markers at the surface. • Rock eval analysis indicates Total organic carbon levels of 5–7 weight per cent within Evie-, Muskwa- and Exshaw-equivalent strata. In addition, there is another zone of high TOC (up to 8 weight per cent) above the Exshaw marker, within the upper part of the Besa River Formation
Partners	This study is part of a collaborative program between the Geological Survey of Canada and the British Columbia Ministry of Energy and Mines, and is under the umbrella of the federal government's Geo-mapping for Energy and Minerals program (GEM).
Key contact	Filippo Ferri, Director, Petroleum Geology, British Columbia Ministry of Energy, Mines and Natural Gas, 250-952-0377, fil.ferri@gov.bc.ca

BRITISH COLUMBIA	
Project/Study Title	**Ultimate Potential for Unconventional Natural Gas in Northeast British Columbia's Horn River Basin**
Project/Study Goal	The study was part of a series of Energy Market Assessments (EMAs) that provide information on the total gas resources of sedimentary basins in Canada. It was a joint assessment produced by the National Energy Board and the British Columbia Ministry of Energy, Mines and Petroleum Resources. In 2010, the National Energy Board and the British Columbia Ministry of Energy and Mines determined that there was enough data to confidently estimate the potential of the Horn River Basin shale play. The report did not specifically address the economics of discovering, developing or producing British Columbia's gas resources
Project description Timeline: July 2010 – May 2011	This is the first publicly released probabilistic resource assessment of a Canadian shale basin. The report focused on estimating the ultimate potential for unconventional natural gas in the Horn River Basin. This was determined by: • reviewing pertinent data, prior studies and other information • mapping some of the geological characteristics of the Muskwa, Otter Park, and Evie shales of the Horn River Basin so that they were in a grid format based on the British Columbia drilling spacing unit • gathering input from industry active in the study area Questions addressed include: • What is the estimate of ultimate potential for unconventional natural gas in the Horn River Basin of northeastern British Columbia? • What is the discovered and undiscovered resource potential in the Horn River Basin? • What is the statistical distribution of the gas-in-place and marketable gas? Office work took place in Calgary, Alberta and in Victoria, British Columbia.
Summary of key findings	This assessment identified a new resource available to British Columbia and Canada and ranked the Horn River Basin among the most prospective shale gas basins in North America. • The estimate of the ultimate gas-in-place (GIP) in the Horn River Basin was determined to be 372 Tcf to 529 Tcf, with the expected outcome of 448 Tcf. • The marketable resource base is expected to be 61 Tcf to 96 Tcf, with the expected outcome of 78 Tcf. The medium case represents the most realistic outcome. • Discovered resources in the Horn River Basin are 3 Tcf and undiscovered

	resources are 75 Tcf (medium case scenarios). Northeastern British Columbia holds about 55 per cent of the reported ultimate remaining conventional and unconventional natural gas resources in the Western Canada Sedimentary Basin. To year-end 2010, and accounting for cumulative gas production in British Columbia of 21.3 Tcf, the estimate of remaining conventional and unconventional natural gas available for future demand was 109 Tcf. This estimate did not consider other unconventional gas resources which are known to exist in British Columbia. There are a number of other unconventional natural gas plays in British Columbia which, if developed, could substantially increase the resource available for Canadian use and export purposes. The National Energy Board and the British Columbia Ministry of Energy and Mines intend to assess British Columbia's plays as time, data, and resources allow.
Partners	This study was part of a collaborative effort between the National Energy Board and the British Columbia Ministry of Energy and Mines.
Key contacts	1- Christopher Adams, Oil & Gas Specialist, British Columbia Ministry of Energy, Mines and Natural Gas, Oil and Gas Division, Geoscience and Strategic Initiatives Branch, Victoria, British Columbia, Phone: (250) 953-3763, Email: Christopher.Adams@gov.bc.ca 2- Filippo Ferri, Director, Petroleum Geology, British Columbia Ministry of Energy, Mines and Natural Gas, 250-952-0377, fil.ferri@gov.bc.ca

BRITISH COLUMBIA	
Project/Study Title	**Geology of the Toad River Area (NTS 094N), Northeast British Columbia**
Project/Study Goal	To undertake fieldwork in the Toad River area, to update the bedrock geological database, constrain the maturation history and provide a geological synthesis of the area.
Project description Timeline: June 2011 – August 2011	This project builds on published and unpublished geological studies, including the detailed mapping along the Liard River prepared for British Columbia Hydro (Geotex Consultants, 1984). New GIS-enabled bedrock geological maps will be produced for the Toad River map area. Each map will include baseline mapping data (location, lithological, structural observations) and baseline data for measured sections (location, observer) together with datasets related to sample acquisition (paleontology reports, Rock Eval™, geochronology and vitrinite reflectance) collected from this project and from historical sources. This report provides the first summary report on the stratigraphy and structure of the Toad River map area since McLearn and Kindle's summary report (1950) on the geology of northeastern British Columbia. Field work occurred northwest of Fort Nelson, British Columbia – western edge of the Laird Basin and office work took place in Victoria, British Columbia.
Summary of key findings	More than 8,000 metres of Mesoproterozoic; Neoproterozoic-Cambrian; Lower, Middle and Upper Paleozoic; Triassic; and Cretaceous strata are exposed in the Toad River, including three organic-rich units with shale gas potential.
Partners	This study is part of a collaborative program between the Geological Survey of Canada and the British Columbia Ministry of Energy and Mines, and is under the umbrella of the federal government's Geo-mapping for Energy and Minerals program (GEM).
Key contact	Filippo Ferri, Director, Petroleum Geology, British Columbia Ministry of Energy, Mines and Natural Gas, 250-952-0377, fil.ferri@gov.bc.ca

BRITISH COLUMBIA	
Project/Study Title	**Possible Use of Water Isotherms to Measure Porosity and Related Properties of Shales**
Project/Study Goal	To measure shale porosity through dehydration of shale cuttings.
Project description Timeline: April 2009 – March 2010	This project generated samples of the Lower Cretaceous Moosebar Formation obtained from wells in the Bubbles, Town and West Beg areas, approximately 150 kilometres northwest of Fort St. John. These were dried through use of saturated salt solutions and measured over a period of time to calculate water isotherms. A key question addressed is: • Can the porosity of a shale or tight reservoir be determined through slow dehydration of representative samples to determine the porosity of the samples and an understanding of the pore sizes?
Summary of key findings	• It is possible to measure porosity in shale cuttings using water isotherms. • This procedure is much less stressful on samples than heating the samples or high pressure mercury injection. • The method provides information on the relative gas permeability • One can obtain information on pore-size distribution • Carefully measuring the rate of moisture escape can provide information on the gas escape rate. • Combining the water isotherm approach with He pyconmetry provides a way to estimate gas saturation.
Partners	This study was led by the British Columbia Ministry of Energy, Mines and Petroleum Resources.
Key contact	Filippo Ferri, Director, Petroleum Geology, British Columbia Ministry of Energy, Mines and Natural Gas, 250-952-0377, fil.ferri@gov.bc.ca

BRITISH COLUMBIA	
Project/Study Title	**Attrition Experiments for the Beneficiation of Unconsolidated Sand Sources of Potential Hydraulic Fracture Sand, Northeast British Columbia**
Project/Study Goal	Determine if attrition of low-silica sand, through tumbling in a mill with steel balls, would be sufficient to remove deleterious sand grains (i.e. non-silica) and improve the silica content of the sands, making them more suitable for use in hydraulic fracturing.
Project description Timeline: April 2010 – March 2011	A homogenous sample of sand was taken from the Fontas Eolian Sand Dune Field, approximately 100 kilometres northeast of Fort Nelson. The sample was split into three sub sets and were processed to determine if: 1) if duration of agitation improved sand quality (i.e. increased amount of quartz sand) of a raw, unscreened sample; 2) if duration of agitation improved sand quality of pre-screened sample and 3) if more aggressive agitation improved sand quality.
Summary of key findings	• Although agitation or light milling of a sand sample will result in degradation of deleterious sand grains, this is insufficient to elevate the quartz content to industry standards for use in hydraulic fracturing. • Although aggressive milling and longer durations produced the greatest increase in quartz content, this also produced angular grains which are not ideal for use as propend material.
Partners	This study is part of a collaborative program between the Geological survey of Canada and the British Columbia Ministry of Energy and Mines, and is under the umbrella of the federal government's Geo-mapping for Energy and Minerals program (GEM).
Key contact	Adrian Hickin, Director, Geoscience, British Columbia Ministry of Energy, Mines and Natural Gas, 250 953-3801, adrian.hickin@gov.bc.ca

BRITISH COLUMBIA	
Project/Study Title	**Preliminary Assessment of Potential Hydraulic Fracture Sand Sources and their Depositional Origin, Northeast British Columbia**
Project/Study Goal	To compile an initial inventory of promising local frac sand sources in consideration of the excessive cost associated with transporting hydraulic fracture proppants ('frac sand') from established sources to northeastern British Columbia, and the anticipated demand that will result from increased development of this area's unconventional shale gas resources.
Project description Timeline: 2009 – 2010	This paper examines the location, nature and origin of naturally occurring quartz rich unconsolidated sand deposits and bedrock outcrop in northeast British Columbia. The deposits were documented during bedrock and surficial geology mapping activities by the British Columbia Ministry of Energy, Mines and Petroleum Resources in partnership with the Geological Survey of Canada. Some of the samples collected during these mapping programs are evaluated here for frac sand potential. The project was centered where shale gas is the target in the Fort St John, Dawson Creek (Montney) and Fort Nelson (Horn River, Cordova Embayment and Liard River) areas. A preliminary assessment of 7 bedrock samples and 17 unconsolidated sand samples from northeast British Columbia is presented. For bedrock samples, thin sections and a distribution map of prospective units in the Rocky Mountain Foothills are provided. For unconsolidated samples, thin sections, grain photographs (binocular, plane light and crossed nicols), major oxide geochemistry and grain-size distribution are provided.
Summary of key findings	Results suggest that the Liard and Charlie Lake formations (Triassic) and the Monteith and Monach formations of the Minnes Group (Late Jurassic to Cretaceous) are the most prospective bedrock units of those assessed. The Liard Formation is mainly a quartz arenite and the Charlie Lake Formation is a feldspathic arenite, both with carbonate cement. The Monteith and Monach formations are quartz arenites. The unconsolidated deposits that are most prospective originate from three depositional environments: glaciodeltaic, aeolian and glaciofluvial. Other findings include: • The Komie area is a priority target, located near the intersection of Geetla and Komie roads on the western edge of the Horn River Basin. It is a glaciofluvial delta (~8 kilometres2) comprising mainly well-rounded, medium-grained quartz-rich sand. • The Redwillow glaciofluvial delta is a large (2 kilometres2) sand deposit south of Dawson Creek with abundant quartz grains mixed with lithic grains.

	• Aeolian deposits of the Fontas Dune Field (Wolfe et al., 2007) contain monocrystalline, fine-grained quartz sand and are an excellent target. • Other potential dune sources are noted in the study.
Partners	This study is part of a collaborative program between the Geological Survey of Canada and the British Columbia Ministry of Energy and Mines, and is under the umbrella of the federal government's Geo-mapping for Energy and Minerals program (GEM).
Key contact	Adrian Hickin, Director, Geoscience, British Columbia Ministry of Energy, Mines and Natural Gas, 250 953-3801, adrian.hickin@gov.bc.ca

BRITISH COLUMBIA	
Project/Study Title	**Implementing Geomatics Technology for Aggregate Exploration, Northeast British Columbia**
Project/Study Goal	To explore for suitable construction aggregate deposits in northeast British Columbia to support the upgrade and construction of oil and gas roads in response to an increase in demand for gravel and a chronic shortage of supply.
Project description Timeline: 2003 – 2005	This paper reviews the geomatics technologies and data that have been used in this program. This project examined hardware, software, data and data processing as applied to aggregate exploration.
Summary of key findings	• Real-time navigation allows for field geologists to gain a more thorough understanding of the characteristics of the region and the relationship between the appearance of features on aerial photographs and on the ground. • Digital field data collection allows for frequent updating of progress in the field and rapid compilation of data in the office. • There exists an exciting potential to further improve on the hardware used in aggregate exploration by implementing new technologies, particularly for field data collection. • The technologies described have helped in the discovery of six deposits with an estimated resource of more than 5 million metres3 of sand and gravel and 24 additional prospects with the potential to host significant quantities of granular material.
Partners	This study was led by the Resource Development and Geoscience Branch, British Columbia Ministry of Energy and Mines.
Key contact	Travis Ferbey, Geological Survey Branch, British Columbia Ministry of Energy, Mines and Natural Gas, 250 953-3773, Travis.Ferbey@gov.bc.ca

BRITISH COLUMBIA	
Project/Study Title	**Geo-Mapping for Energy and Minerals Program (GEM-Energy): Preliminary Surficial Geology, Geomorphology, Resource Evaluation and Geohazard Assessment for the Maxhamish Lake Map Area (NTS 094O), Northeastern British Columbia**
Project/Study Goal	The project goal is to provide reliable geoscience information on surficial earth materials, geohazards and resource potential for granular aggregate, frac sand and groundwater to government agencies, industry, communities and the public access.
Project description Timeline: April 2010 – March 2011	The main objectives of this project are to provide observation-based conclusions on the following key questions: • What is the distribution of surficial deposits and landforms? • Can granular aggregate deposits or potential deposits be identified? • Can sources for frac sand be identified? • How much of the region is susceptible to geohazards? This project focuses on the surficial geology units and landforms mapped and classified on the Maxhamish Lake map sheet (NTS 094O), an area of approximately 12,624 kilometres2 in northeastern British Columbia This is a preliminary evaluation of the potential for granular aggregate, possible frac sand sources and baseline assessment of geohazards in the study area. The project is a compilation of regional-scale information on surficial deposits and landform processes in northeastern British Columbia built from: • the knowledge of other regional studies and surficial mapping projects • remote predictive terrain classification and digital mapping • benchmarking field-based studies on the regional distribution of surficial deposits, permafrost, landslides and other geomorphic processes • integrating knowledge on the limits of glaciation, the range of subglacial processes, the patterns of ice flow, and the history of ice retreat and glacial lake formation during a dynamic period of climate change and geomorphic adjustment.
Summary of key findings	• Surficial geology maps and related databases were created for the Maxhamish Lake map area to help identify, classify and evaluate the potential for granular aggregate, frac sand sources, groundwater and geohazards, and are available for digital download or from CD-ROM. • In the region underlain by the parts of the gas-producing Horn River and Liard basins, key surface exploration targets for granular aggregate are glaciofluvial landforms include: eskers, terraces, meltwater

	channels and spillways.
	• As well, on-site and laboratory-based assessments indicate:
	  ○ that most glaciofluvial deposits in the map area have low to moderate potential as granular aggregate sources.
	  ○ Eolian deposits may be a viable source for frac sand. Unfortunately, these deposits and landforms have a limited geographic extent.
	  ○ Polygons mapped with silt- and clay-rich till as the dominant terrain unit are suitable for well pads, building sites, road bases and other infrastructure development.
	• Geohazards include:
	  ○ mass-wasting of glacial sediment and bedrock on the slopes of stream and river valleys, escarpments and upland plateaus (4.4% of the study area);
	  ○ flooding, erosion, deposition and beaver activity in valleys (affecting 5.7% of the study area);
	  ○ and undifferentiated organic deposits and peat bogs containing sporadic discontinuous permafrost blanketing till and glaciolacustrine deposits (12.7% of map area) on the Liard and Etsho plateaus and the Fort Nelson Lowland.

Partners	This study is part of a collaborative program between the Geological Survey of Canada and the British Columbia Ministry of Energy and Mines, and is under the umbrella of the federal government's Geo-mapping for Energy and Minerals program (GEM).
Key contact	Adrian Hickin, Director, Geoscience, British Columbia Ministry of Energy, Mines and Natural Gas, 250 953-3801, adrian.hickin@gov.bc.ca

BRITISH COLUMBIA	
Project/Study Title	**Potential for Freshwater Bedrock Aquifers in Northeast British Columbia: Regional Distribution and Lithology of Surface and Shallow Subsurface Bedrock Units**
Project/Study Goal	The goal of this project is to identify data sources and previous work that provide tools for freshwater resource exploration and describe the characteristics of shallow (<600 metres) bedrock units in terms of their predicted hydrostratigraphic properties (i.e., aquifer versus aquitard), lithology and distribution.
Project description Timeline: April 2011 – March 2012	The main objectives of this project are to provide observation-based conclusions on the following key question: Which bedrock strata in Northeast British Columbia are most likely to host freshwater bedrock aquifers? The project focused on northeastern British Columbia, roughly between Dawson Creek and the NWT border.
Summary of key findings	• Freshwater bedrock aquifers are mainly hosted by Cretaceous strata in northeast British Columbia and the most important prospective regional bedrock units for freshwater aquifers are the coarse clastic Wapiti and Dunvegan formations. • In the Peace River valley, bedrock aquifers have provided fresh water to meet domestic, agricultural and commercial demands and some of these aquifers have been delineated and studied. • Bedrock aquifer yields in the Peace River area are generally much lower than those of surficial aquifers, but can be adequate for domestic, not industrial, needs. Fracture porosity, however, can substantially enhance yields in both coarse clastic and shale units. • The Kotaneelee, Puskwaskau, and Kaskapau formations and the majority of Fort St. John Group are mainly shale units that can be expected to behave as regional aquitards; however, minor coarse clastic units in these formations may host small aquifers. Fractured shale units are known to host freshwater aquifers in the Peace River valley and may be present in other regions. • Water quality is generally better (lower in dissolved solids) in the Rocky Mountain Foothills and poorer on the plains. This characterization is supported in the Peace River valley, where significant data exist and it is reasonable to expect that it will hold true throughout northeast British Columbia. Additional observations regarding data gaps and detailed stratigraphic studies in the context of fresh groundwater are in the study.
Partners	This study was led by the British Columbia Ministry of Energy and Mines.
Key contact	Janet Riddell, Geologist, Mines and Mineral Resource Division, Ministry of Energy, Mines and Natural Gas, Victoria, British Columbia, Phone: (250) 952-0350, Email: Janet.Ridell@gov.bc.ca

BRITISH COLUMBIA	
Project/Study Title	**Provisional Surficial Geology, Glacial History and Paleogeographic Reconstructions of the Toad River (NTS 094N) and Maxhamish Lake Map Areas (NTS 094O), British Columbia (NTS 094B/14)**
Project/Study Goal	The project goal is to reduce the impact of geohazards upon infrastructure and to promote sustainable long-term investment and economic development in the eastern Liard Basin and Fold Belt and the Horn River Basin shale gas producing regions of northeastern British Columbia by understanding of surficial geology and glacial history.
Project description Timeline: April 2010 – March 2011	The main objectives of this project are to provide observation-based conclusions on the following key questions: • What is the distribution of surficial deposits and landforms? • How much of the region is susceptible to geohazards? • What is the extent and iceflow patterns of the Laurentide and Cordilleran ice sheets? • What is the distribution of glaciofluvial and glaciolacustrine deposits, meltwater features and drainage directions? • What is the distribution of colluvial deposits, landslides and permafrost? • What is the extent and nature of eolian deposits? This project focuses on the surficial geology units, landslides, permafrost and other geomorphic processes on the Toad River and Maxhamish Lake map sheets, an area of approximately 25,000 kilometres2 in northeastern British Columbia This is a preliminary evaluation of the potential for granular aggregate, possible frac sand sources and baseline assessment of geohazards in the study area. The project is a compilation of regional-scale information on surficial deposits and landform processes in northeastern British Columbia that is built from: • the knowledge of other regional studies and surficial mapping projects • remote predictive terrain classification and digital mapping • benchmarking field-based studies on the regional distribution of surficial deposits, permafrost, landslides and other geomorphic processes • integrating knowledge on the limits of glaciation, the range of subglacial processes, the patterns of ice flow, and the history of ice retreat and glacial lake formation during a dynamic period of

	climate change and geomorphic adjustment.
Summary of key findings	The following were identified as critical to reduce the risks for exploration of energy, mineral and forest resources in northeastern British Columbia: • knowledge of the extent and iceflow patterns of the Laurentide and Cordilleran ice sheets; • the distribution of glaciofluvial and glaciolacustrine deposits, meltwater features and drainage directions; • the distribution of colluvial deposits, landslides and permafrost; • and the extent and nature of eolian deposits Other findings include: • New insights into the glacial history and paleogeography of the Toad River and Maxhamish Lake map areas. • Forest fires may have been a key trigger for landslide activity on slopes. • Watersheds are prone to disruption by beavers, and to a lesser extent, by humans. • Based on remote predictive mapping and field observations from 2003 to 2010, the landscape evolution model is geomorphologically robust. More details on findings regarding the landscape, topography and drainage patterns can be found within the study.
Partners	This study is part of a collaborative program between the Geological Survey of Canada and the British Columbia Ministry of Energy and Mines, and is under the umbrella of the federal government's Geo-mapping for Energy and Minerals program (GEM).
Key contact	Fil Ferri, A/Director , Geoscience and Strategic Initiatives, Oil and Gas Division, Ministry of Energy, Mines and Natural Gas, Victoria, British Columbia , Phone: (250) 952-0377

BRITISH COLUMBIA	
Project/Study Title	**Water Potential of the Mississippian Debolt Formation in the Horn River Basin, Northeastern British Columbia**
Project/Study Goal	The goal of this study was to provide a cursory assessment on the suitability of subsurface strata in the Horn River Basin, in particular the Debolt Formation, to host aquifers that would meet the increasing water demand associated with shale gas development.
Project description Timeline: November 2008 – January 2009.	The main objectives were to address the following questions: • Which geologic formations could potentially supply water for shale gas development in the Horn River Basin? • Is there sufficient information to map geologic aspects of the Debolt Formation from a water resource perspective? • Where are overlying potential aquifers located? The project focused on the Horn River Basin in northeastern British Columbia, a region between Fort Nelson, British Columbia and the NWT border. The geology and stratigraphy of the Debolt Formation was described and potential water-bearing formations are described by wells that had produced water.
Summary of key findings	Key findings include: • Cretaceous and Mississippian sandstones and limestones are considered the most likely source rocks for water in sufficient quantity to meet drilling and hydraulic fracturing requirements. • Drilling has increased rapidly, but geologic knowledge is still highly limited, especially in the centre portion of the basin. • The Mattson and Golata provide a potential source along the far west of the basin boundary, but the Debolt is the primary horizon of interest as it is a thick, basin-wide, porous unit. • While the Debolt has good permeability in some areas, there are also broad regions of very low permeability. Knowledge of which portion of the Debolt is in contact with the unconformity, its porosity characteristics, and which formations are proximal will aid in determining zones of secondary porosity with increased permeability. • Better control is needed to understand depositional and diagenetic controls on porosity and permeability.
Partners	This study was completed internally by the British Columbia Ministry of Energy and Mines.
Key contact	Elizabeth Johnson, Senior Hydrogeologist, Geoscience and Strategic Initiatives Branch, Oil & Gas Division, Ministry of Energy, Mines and Natural Gas, Victoria, British Columbia , Phone: (250) 952-0418, Elizabeth.Johnson@gov.bc.ca

BRITISH COLUMBIA	
Project/Study Title	**Stratigraphy and Proposed Geophysical Survey of the Groundbirch Paleovalley: A Contribution to the Collaborative Northeast British Columbia Aquifer Project**
Project/Study Goal	The goal of the project was to delineate the geological framework of the unconsolidated aquifers within the Groundbirch paleovalley.
Project description Timeline: April 2011 – March 2012	The main objectives of this project were to provide observation-based conclusions on the following key question: • Can viable aquifers be located and characterized within the Groundbirch paleovalley? A geologic framework was constructed by integrating three geophysical surveys with other data. Downhole electromagnetic and gamma surveys were conducted in a deep observation well which provided detailed geology used to calibrate the other surveys. A ground-based time-domain electromagnetic survey and a shallow seismic reflection survey were carried out to provide two-dimensional sections across the paleovalley. This information was supplemented by field and water well data. The study area is located in northeastern British Columbia and encompasses the region between the British Columbia–Alberta border and east to the Murray–Pine rivers.
Summary of key findings	Preliminary results are only available and they include: • The Groundbirch paleovalley was identified in several studies as an important groundwater feature but there is a need for a more thorough groundwater evaluation to understand the aquifers in this groundwater system. • Although there is abundant water-well information available in this area from the British Columbia Ministry of Environment WELLS database, the quality of the geological data is questionable. • Discrepancies in mapped stratigraphy indicate units vary locally and the geology is unpredictable. This complexity is clearly apparent in the lower Coldstream River section where coarse-grained units are laterally discontinuous.
Partners	The British Columbia Ministry of Forests, Lands and Natural Resource Operations partnered with the British Columbia Ministry of Energy and Mines, the British Columbia Ministry of Environment, Simon Fraser University and the Geological Survey of Canada.
Key contact	Adrian Hickin, Director, Mines and Mineral Resource Division, Ministry of Energy, Mines and Natural Gas, Victoria, British Columbia, Phone: (250) 953-3801 | Email: Adrian.Hickin@gov.bc.ca

BRITISH COLUMBIA	
Project/Study Title	**Conceptual Water Model for the Horn River Basin, Northeast British Columbia**
Project/Study Goal	The goal of this research is to outline important information sources for the Horn River Basin and identify features that will affect hydrological predictions in the region.
Project description Timeline: April 2009 – March 2010	The main objectives of this project are to provide observation-based conclusions on the following key questions: • What data is publicly available for the Horn River Basin? • What water model types and regional models in existence for the Horn River Basin? • What are the hydrogeological implications of important complexities particular to the Horn River Basin (including climate, permafrost, lakes and streams and muskeg)? • What information gaps can be identified? The project focused on the Horn River Basin in northeastern British Columbia, a region between Fort Nelson, British Columbia and the North Western Territories border. Water availability can be generated for this region by modelling but the integration of much data is required. Data sources and potential sources are identified. The challenge of generating representative water availability forecasts is clearly presented and previous modelling efforts are presented. As well, factors controlling the hydrogeology are described in detail.
Summary of key findings	Generating a sound numerical water model is challenging for northeast British Columbia because of the complications introduced by discontinuous permafrost, widespread patchy muskeg, low relief and a lack of ground-based observations. Key findings include: • Climate analysis indicates that precipitation is not uniform across the Horn River Basin. Evapotranspiration is a very important component in a water balance, at times exceeding precipitation, but it varies with water table, lake distribution and vegetation type. • The depth, thickness and duration of ground frost and permafrost control subsurface flow, infiltration and recharge rates. • The distinction between fen and bog is imperative to understanding and predicting stream discharge. Fens indicate interaction with laterally flowing groundwater, whereas bogs represent the storage of water and regions of potential permafrost.

	• Water models should account for groundwater. While the groundwater component in the water balance may be minor, it represents the mechanism by which peatlands retain water, lakes and uplands exchange water, and streamwater quality and quantity is maintained.
Partners	This study was completed internally by the British Columbia Ministry of Energy and Mines.
Key contact	Elizabeth Johnson, Senior Hydrogeologist, Geoscience and Strategic Initiatives Branch, Oil & Gas Division, Ministry of Energy, Mines and Natural Gas, Victoria, British Columbia , Phone: (250) 952-0418, Elizabeth.Johnson@gov.bc.ca

ALBERTA	
Project/Study Title	**Summary of Alberta's Shale- and Siltstone-Hosted Hydrocarbon Resource Potential**
Project/Study Goal	Provide baseline data, information, and understanding of the geology, distribution, reservoir characteristics, and hydrocarbon resource potential of Alberta shales.
Project description Timeline: 2006 - October 2012	The study focused on shale gas in formations for which industry had shown interest. As it progressed, it was found that many of the formations also contained a significant amount of natural-gas liquids and oil so the study was expanded to include all shale- and siltstone-hosted hydrocarbons. The geology, distribution, characteristics, and hydrocarbon potential of key 'shale' units in Alberta were evaluated. Preliminary Estimates of hydrocarbon resource potential in 6 of an identified 15 formations with shale resource potential were provided. Five of these show immediate potential: the Duvernay, the Muskwa, the Montney, the Nordegg, and the basal Banff and Exshaw (occasionally referred to as the Alberta Bakken). The study also includes a preliminary assessment of the Colorado, Wilrich, and Rierdon units, a summary of the Bantry Shale unit, and included the Montney Formation as a target for unconventional resources. All units were systematically mapped, sampled, and evaluated for their hydrocarbon potential. The process included • collecting samples from core and outcrop exposures; • analyzing the samples to determine the physical and chemical characteristics of the rocks; • evaluating geophysical well logs to determine rock properties and reservoir characteristics; and • using geostatistical methodologies to aid in interpolation and to quantify uncertainty.
Summary of key findings	The report contains Natural Gas, Oil and Natural Gas Liquid preliminary resource estimates at P10, P50 and P90 confidence levels for the five units of immediate potential as well as a sixth, Wilrich
Partners	Partners included the Ministry of Alberta Energy, and the Alberta Geological Survey of the Energy Resources Conservation Board (lead).
Key contact	Andrew Beaton, Manager, Energy Resource Appraisal, ERCB, E-mail: andrew.beaton@ercb.ca, Phone: (780) 427-3272

ONTARIO	
Project/Study Title	**An Investigation of Potential Shale Gas Units in Southern Ontario (provides hyperlink to 2012 summary of field work)**
Project/Study Goal	The main purpose of this project is to evaluate the potential of "black shale" units in two areas of Southern Ontario to generate shale gas. A secondary goal is to investigate the possible connection between shale gas and documented gas occurrences in water wells.
Project description Timeline: 2009 – Summer 2014	Questions addressed within the study include: • Are organic-rich "black shale" formations in southern Ontario potential sources of shale gas? • What is the character and potential origin of natural gas found in these black shales? • What controls the formation of shale gas in these units? • Is there a connection between shale gas and natural gas found in water wells? The project began with a review of available literature and data. There were considerable basic data available for the units of interest (Kettle Point Formation and the Collingwood-Rouge River units) as they had been studied by the OGS in the 1980s as potential oil shales. Available cores and chip samples from industry exploration and previous OGS research drilling programs were sampled and analyzed for parameters such as total organic content and thermal maturity. Three new research cores were acquired (2 of the Kettle Point Formation and 1 of the Collingwood-Rouge River units) so that fresh samples could be analyzed for gas content, composition and character. Parameters measured included: gas content over time, gas composition, isotopic composition of methane, and gas adsorption isotherms. Core analyses included: rock mechanics properties, total organic carbon, density, gas, oil and water saturation, permeability and porosity.
Summary of key findings	Preliminary results have been published in annual summaries of field work. Final results should be released as Open File Reports in June 2013 (Kettle Point Formation) and summer 2014 (Ordovician Gas Shales). This include results for the various parameters measured (total organic content, porosity, thickness, etc.) for the units of interest. In addition, the following was found: • Kettle Point Formation has generated biogenic shale gas and can be considered a prospective resource, however detailed property-scale analysis of organic matter content, gas content, mineralogy and mechanical properties among other considerations are required to evaluate economic prospectivity. Based on spatial proximity and very preliminary science data, this formation is also a likely source of the

	natural gas that occurs in some of the water wells in this part of Ontario. • The Upper Ordovician Collingwood and Rouge River members contain thermogenic gas. The lack of biogenic gas suggests these units are not connected with near surface fresh groundwater (there may be some connection within the actual outcrop belt). Relatively low thermal maturity suggests these units may have limited prospectivity for shale gas.
Partners	The project was undertaken by the Ontario Geological Survey, Ministry of Northern Development and Mines. The Ontario Ministry of Natural Resources provided input during the early part of the project.
Key contact	Shale Gas: Derek Armstrong (filling in for Catherine Béland Otis), Geoscientist, Earth Resources & Geoscience Mapping Section, Ontario Geological Survey, Ministry of Northern Development & Mines, 705-670-5913, derek.armstrong@ontario.ca Ambient Groundwater Geochemistry Program: Stewart Hamilton, Geochemist, Earth Resources & Geoscience Mapping Section, Ontario Geological Survey, Ministry of Northern Development & Mines, 705-670- 5915, stew.hamilton@ontario.ca
Additional hyperlinks	Links to Shale Gas Project publications: 2011 summary of field work (article #26): www.geologyontario.mndmf.gov.on.ca/mndmfiles/pub/data/imaging/OFR6270/OFR6270.pdf 2010 summary of field work (article #38): www.geologyontario.mndmf.gov.on.ca/mndmfiles/pub/data/imaging/OFR6260/OFR6260.pdf 2009 summary of field work (article #30): www.geologyontario.mndmf.gov.on.ca/mndmfiles/pub/data/imaging/OFR6240/OFR6240.pdf Links to Ambient Groundwater Geochemistry Program data and reports: Ambient Groundwater Geochemistry Data (MRD 283): www.geologyontario.mndmf.gov.on.ca/mndmaccess/mndm_dir.asp?type=pub&id=MRD283 Ambient Groundwater Geochemistry Data in Google Earth format: www.mndm.gov.on.ca/en/mines-and-minerals/applications/ogsearth/ambient-groundwater-geochemistry 2007 summary of field work (article #20): www.geologyontario.mndmf.gov.on.ca/mndmfiles/pub/data/imaging/OFR6213/OFR6213.pdf

QUÉBEC	
Project/Study Title	**Potentiel en gaz naturel dans le Groupe d'Utica, Québec (Natural gas Potential in the Utica Group, Québec)**
Project/Study Goal	The goal of the report is to determine, on the basis of available information, the characteristics of the Utica Group compared to other natural gas-producing basins in North American shales (Barnett, Marcellus, Montney and Haynesville). *N.B.: This document was produced as part of the strategic environmental assessment (SEA) on shale gas. The opinions expressed in this document are those of the authors and do not necessarily reflect those of the Strategic Environmental Assessment Committee on Shale Gas or the Québec Department of Sustainable Development, Environment and Parks.*
Project description Timeline: 2011 - September 2012	Identify the geological, geochemical and petrophysical characteristics of the Utica Group. Compare the geological, geochemical and petrophysical characteristics of the Utica Group of the St. Lawrence Lowlands with those of the gas-bearing basins of the Barnett, Marcellus, Haynesville and Montney Shales. Comparative study of the various estimates of the gas potential of the Utica Group in the St. Lawrence Lowlands. This report also sought to estimate the in-place gas resource, document the natural gas reserves in North American gas-bearing shales and validate the gas resource estimates provided during the public hearings on the sustainable development of the shale gas industry in Québec held by the Québec Bureau d'audiences publiques sur l'environnement (BAPE) in 2011.
Summary of key findings	The Utica Group in Québec is divided into two units, the Upper and Lower Utica. The Upper Utica is slightly richer in limestone and has a higher total organic carbon content. The thickness of the Utica Group varies depending on its geographic position. Organic matter maturation generally increases toward the southeast, with the burial of the basin. The high maturation level of the Utica Group in corridors 2 and 3 suggests that hydrocarbon generation has ended and that this formation largely contains dry gas, with little or no gas liquids. The surface area, depth and mineralogy of the Utica Group are all comparable to various other producing gas shales in North America, although this formation has greater thickness than the analogous basins analyzed. However, the organic carbon content and porosity values are lower than average.

	The in-place gas potential could be from 100 Tcf to more than 300 Tcf. The technically recoverable portion of this resource is estimated at between 22 Tcf and 47 Tcf. [N.B.: 1 Tcf (trillion cubic feet) is equal to 10^{12} ft^3]
Partners	Department of Geology and Geological Engineering, Laval University, and various consultants
Key contact	Georges Beaudoin, Full Professor, Faculty of Science and Engineering, Department of Geology and Geological Engineering, Laval University Telephone: (418) 656-3141 e-mail: georges.beaudoin@ggl.ulaval.ca

QUÉBEC	
Project/Study Title	**Synthèse géologique et hydrogéologique du Shale d'Utica et des unités sus-jacentes (Lorraine, Queenston et dépôts meubles), Basses-Terres du Saint-Laurent, Québec (Geological and hydrogeological synthesis of the Utica Shale and overlying units (Lorraine, Queenston and unconsolidated deposits), St. Lawrence Lowlands, Québec)**
Project/Study Goal	The goal of this synthesis is to provide guidance for future studies aimed at assessing the degree of geological impermeability of the rock successions between the target shales for shale gas development and shallow aquifers, in unconsolidated deposits or fractured rock. This synthesis was intended specifically to identify regions or types of data for which there is little information, to assist in making choices concerning future scientific research on the issue of shale gas in Québec. *N.B.: This document was produced as part of the strategic environmental assessment (SEA) on shale gas. The authors are responsible for the selection and presentation of the facts. The opinions expressed in this document are those of the authors and do not necessarily reflect those of the Strategic Environmental Assessment Committee on Shale Gas or the Québec Department of Sustainable Development, Environment and Parks.*
Project description Timeline: 2009 - 2013	This report is the initial product of a four-year research project being conducted by the Earth Sciences Sector of Natural Resources Canada dealing with the assessment of the geological integrity of the cap rock overlying potential gas-bearing shale units in eastern Canada (Québec, New Brunswick and Nova Scotia). The initial mandate in Québec involved the production of a synthesis of knowledge and public data available on the Utica Shale and overlying units, Quaternary sediments included, in the St. Lawrence Lowlands, with an emphasis on representing the stratigraphic and structural relationships, particularly between the Utica Shale and near-surface bedrock aquifers. The document is divided into three sections: • The first section examines geological questions and places in context the Utica Shale and the overlying Lorraine and Queenston Groups in the St. Lawrence Lowlands, presenting the tectonic and stratigraphic relationships of importance for this study. This section then examines the physical and chemical properties of the various units. • The second section, which also deals with geological questions, presents the structural models developed as well as the chosen methodology. • The third section considers hydrogeological issues and documents the progress of the Programmes d'acquisition de connaissances sur

	les eaux souterraines du Québec (PACES) [Québec groundwater knowledge acquisition programs] as well as the data available to characterize the shallow (unconsolidated deposits and fractured rock) and deep (bedrock) hydrogeological environments.
Summary of key findings	The geological and hydrogeological synthesis demonstrates that there are no real geographic gaps in the coverage of the data currently available (geology and oil and gas drilling) or that will be available by the end of the projects currently being conducted as part of the PACES (i.e. in 2013 and in 2015). There are still some gaps in the subsurface geological data in the southeastern sector (the Appalachian domain), but this region does not appear to be of immediate interest for shale gas exploration and development. The data is incomplete in certain specific areas, particularly concerning the regional tectonostratigraphic framework, the physical and chemical properties of the deep hydrogeological environment, and the integrity of the overlying cap rock of the Utica Shale.
Partners	The report was written by the Institut National de la Recherche Scientifique, Centre Eau Terre Environnement, and submitted to the Geological Survey of Canada (GSC) and the Québec Department of Sustainable Development, Environment and Parks.
Key contact	Denis Lavoie, Research Scientist, Geological Survey of Canada (GSC-Québec), Québec City, QC, Telephone: (418) 654-2571, e-mail: delavoie@nrcan.gc.ca

QUÉBEC	
Project/Study Title	**L'industrie du gaz de schiste dans les Basses-Terres du Saint-Laurent : scénarios de développement (Shale gas industry in the St. Lawrence Lowlands: development scenarios)**
Project/Study Goal	In accordance with its mandate, the Strategic Environmental Assessment Committee (SEAC) is conducting numerous studies with the aim of meeting the knowledge requirements concerning the exploration and development of gas resources in the Utica Shale in Québec. In order to facilitate analysis of all the environmental, social, financial and economic impacts associated with the activities of the shale gas industry for a given situation, the SEAC is endeavouring to establish parameters for the parties that will be commissioned to conduct the assessment of these impacts by developing a limited number of plausible scenarios for the development of this industry in the Utica Shale of the St. Lawrence Lowlands. *N.B.: The scenarios presented in this document are intended to be neutral, i.e. they are not based on any prior decision made or instruction given by the Strategic Environmental Assessment Committee on Shale Gas, and their sole purpose is to define common parameters for all the studies commissioned as part of the strategic environmental assessment.*
Project description Timeline: 2011 – November 2012	The SEAC has selected five plausible development scenarios for the gas sector covering all possibilities over a 25-year timeframe, ranging from "no development" to "large-scale development" of the shale. These scenarios were developed based on the results of studies that examined a typical project (CIRAIG, 2012) as well as on Québec's gas potential (Duchaine et al., 2012), information obtained from certain companies that hold exploration licences in the Utica Shale as well as official documents, mainly from government and university sources. At the SEAC's request, a modeling tool in the form of an Excel spreadsheet was developed in order to incorporate all the variables described above. The modeling tool first calculates the values associated with a typical well and then aggregates the data for all the wells covered by a scenario. For each development scenario, the tool performs the following specific functions: • calculates the total volumes of gas produced; • produces a typical decline curve for the Utica Shale; • conducts sensitivity analyses on various variables; • incorporates a module simulating the well drilling rate; • considers the private and public discount rates; • calculates royalties; • determines the breakeven points.

	This modeling tool will be used to present and characterize each scenario based on the variables measured.
Summary of key findings	The goal of this project was to study five plausible development scenarios for the gas sector covering all possibilities over a 25-year timeframe, ranging from “no development” to “large-scale development” of the shale. Strictly speaking, this study does not present any conclusions. The reader is encouraged to consult the study for a presentation of the scenarios and hypotheses used.
Partners	Strategic Environmental Assessment Committee on Shale Gas (Government of Québec)
Key contact	Strategic Environmental Assessment Committee on Shale Gas (Government of Québec)

NORTHWEST TERRITORRIES	
Project/Study Title	**Regional Geoscience Studies & Petroleum Potential Of Mackenzie Plain Area, Central NWT**
Project/Study Goal	To improve the geological knowledge of the Mackenzie Plain area of the central NWT through a 5-year (2009-2014) geoscience study of field outcrops and subsurface data.
Project description Timeline: 2009 - 2014	Outcrop and well data for the Mackenzie Plain region were analyzed over a four year period with analytical results published annually as NTGO Open Files or Open Reports. The study area is broadly defined by the region of 63 degrees 30 minutes N to 66 degrees N latitude and 123 degrees W to 130 degrees W longitude. The outcrop studies entailed measuring and description of sections of the Horn River Formation (Canol Formation and Bluefish Member) together with acquisition of samples across 2 m intervals. These were analyzed for organic geochemistry by Rock-Eval pyrolysis, and lithogeochemistry. Gamma ray spectrometry data was acquired every metre via a hand held spectrometer and representative samples were taken for thermal maturation determination by reflective light microscopy. In addition, samples were taken for microfossil analysis and age dating. Gamma ray logs and other data were used to create logs that could be used to correlate the unit into similar sections in the subsurface. Wells in the study area were sampled with permission from the NEB and analyzed for organic geochemistry by Rock-Eval pyrolysis, and lithogeochemistry. The overlying sandstone and shale of the Imperial Formation was collected for analysis of porosity/permeability and Rock-Eval/total organic carbon. The underlying limestone and shale of the Hume Formation was also collected for oil extraction analysis, porosity/permeability and Rock-Eval/total organic carbon. Questions addressed include: • thickness; • composition; • thermal maturity; • organic and litho geochemistry; • mineralogy • and correlation into the subsurface. See http://www.nwtgeoscience.ca/petroleum/mackenzie_plain.html

Summary of key findings	• The Canol Formation and the Bluefish Member of the Horn River Group are good to excellent quality source rocks in the Mackenzie Plain with TOC averages between 1 – 8%. Type II (oil prone) kerogen is indicated with a contribution from Type III kerogen. The Canol Formation is mature (within the oil window) through most of the Mackenzie Plain and over mature to the south. • Horn River Group is widespread in the subsurface. Thicknesses range from tens to hundreds of meters. • Vitrinite reflectance studies generally agree with the Rock-Eval data, and increasing maturity from northeast to west and south. • Quartz is the dominant mineral in the Canol Formation averaging 82 to 90 % of the rock volume.
Partners	This study is part of a collaborative program between the Northwest Territories Geoscience Office and the Geological Survey of Canada, under the umbrella of the federal government's Geo-mapping for Energy and Minerals program (GEM).
Key contact	Kathryn Fiess, Manager, Petroleum Geosciences, Northwest Territories Geoscience Office, Yellowknife, NWT, Phone (867) 669-2488; email Kathryn_Fiess@gov.nt.ca

NORTHWEST TERRITORIES	
Project/Study Title	**The Hydrocarbon Potential of the Devonian to Mississippian Age Shales in the Liard Basin of the NWT.**
Project/Study Goal	Evaluate the unconventional hydrocarbon potential of the Devonian to Mississippian age shale units in the NWT portion of the Liard Basin.
Project description Timeline: 2012-2015	The joint NWT-YT-BC Liard Basin hydrocarbon Project is a multi-year (2012-15) field- and laboratory-based investigation of the stratigraphy of Devonian-Mississippian shale units of the Liard Basin with regards to their potential to host unconventional hydrocarbon resources. Outcrop and well data for the Liard Basin region will be analyzed over a three year period with analytical results published annually as NTGO Open Files or Open Reports. The study area is broadly defined by the region of 59 degrees 50 minutes N to 61 degrees N latitude and 123 degrees W to 125 degrees 30 minutes W longitude. The outcrop studies entail measuring and description of sections of the Devonian to Carboniferous age Besa River shales (Golata Formation and Besa River Formation) together with acquisition of samples across 2 m intervals. These will be analyzed for organic geochemistry by Rock-Eval pyrolysis, and lithogeochemistry. Gamma ray spectrometry data was acquired every metre via a hand held spectrometer and representative samples were taken for thermal maturation determination by reflective light microscopy. In addition, samples were taken for microfossil analysis and age dating. Gamma ray logs and other data were used to create logs that could be used to correlate the unit into similar sections in the subsurface. Where possible, wells in the study area will be sampled with permission from the NEB and analyzed for organic geochemistry by Rock-Eval pyrolysis, and lithogeochemistry. The overlying sandstone and shale of the Mattson Formation may be collected for analysis of porosity/permeability. Questions addressed include: • thickness; • composition; • thermal maturity; • organic and litho geochemistry; • mineralogy • and correlation into the subsurface.
Summary of key findings	Analytical work in progress.

Partners	The first year of this study was part of a collaborative program between the Northwest Territories Geoscience Office and the Geological Survey of Canada, under the umbrella of the federal government's Geo-mapping for Energy and Minerals program (GEM), Yukon Geological Survey and the British Columbia Ministry of Energy and Mines.
Key contact	Kathryn Fiess, Manager, Petroleum Geosciences, Northwest Territories Geoscience Office, Yellowknife, NWT, Phone (867) 669-2488; email Kathryn_Fiess@gov.nt.ca

NORTHWEST TERRITORIES	
Project/Study Title	**Regional Characterization of Shale Gas and Shale Oil Potential, Northwest Territories**
Project/Study Goal	Regional-scale study of the unconventional shale oil & gas potential of the southern and central Northwest Territories.
Project description Timeline: 2010- 2011	Available outcrop and subsurface data were compiled and assessed to determine shale hydrocarbon potential within two study areas. These areas include the southern Liard – Great Slave study area, and the northern Peel-Mackenzie study area.
Summary of key findings	1. Liard – Great Slave • Good potential in Devonian Muskwa-Horn River formations, Devonian/Mississipian Exshaw Formation, and Cretaceous Fort St. John Group 2. Peel – Mackenzie • Devonian Horn River Group and Cretaceous Slater River Formation are prospective. • Imperial and Arctic Red shales are organic-lean.
Partners	None
Key contact	Kathryn Fiess, Manager, Petroleum Geosciences, Northwest Territories Geoscience Office, Yellowknife, NWT, Phone (867) 669-2488; email Kathryn_Fiess@gov.nt.ca

NORTHWEST TERRITORIES	
Project/Study Title	**Identification of Potential Silica Sand Deposits in the Northwest Territories**
Project/Study Goal	The main objective of this study was to research and map prospective bedrock and unconsolidated silica sand deposits within the Mackenzie Corridor between the NWT-Alberta border and the Fort Good Hope area.
Project description Timeline: 2012	Desktop study/compilation of potential frac sand source formations from published and unpublished data.
Summary of key findings	Prospective bedrock formations: • Liard River Valley: Carboniferous Mattson and Cretaceous Sikanni, Scatter, and Dunvegan formations. • Mackenzie River: Proterozoic Katherine Group and Cambrian Mount Clark. • Great Slave Lake: Proterozoic Preble, Kluziai, and Hornby Channel formations and the Cambrian Old Fort Island Formation. 2. Prospective Quaternary sand units: • Dune fields that have re-worked older sediments and/or sandstones along the Mackenzie River in the Fort Good Hope, Mountain River, Tulita, Keele River, and Fort Simpson areas. • Sandy glaciofluvial deposits along the Liard Highway. • Paleo-beaches and dunes along the North Arm of Great Slave Lake.
Partners	None
Key contact	Kathryn Fiess, Manager, Petroleum Geosciences, Northwest Territories Geoscience Office, Yellowknife, NWT, Phone (867) 669-2488; email Kathryn_Fiess@gov.nt.ca

NORTHWEST TERRITORIES	
Project/Study Title	**Preliminary Assessment of Silica Sand Resources of the Northwest Territories**
Project/Study Goal	Samples were collected from previously identified and new sources of silica sand to determine their suitability for various purposes including frac sand.
Project description Timeline July 2012 – November 2013	Samples were collected from aeolian sands, glaciofluvial deposits and consolidated bedrock deposits throughout the Northwest Territories. The samples will be assessed for suitability (roundness, sphericity, mineralogy and size distribution) in-house to determine a need for follow-up work. A preliminary report will be published fall 2013.
Summary of key findings	Work is in progress. Field observations suggest that the aeolian and glaciofluvial sands will not meet the requirements for frac sand usage.
Partners	None
Key contact	David Watson, Publications Geologist, Northwest Territories Geoscience Office, Yellowknife, NWT, Phone (867) 669-2475; email David_Watson@gov.nt.ca

C) Managing Environmental Impacts

FEDERAL	
Project/Study Title	**Characterizing Deep Subsurface Aquifers for Water Supply and Disposal, Supporting NWT Shale Gas Development**
Project/Study Goal	The objectives of this project are to identify and characterize deep subsurface aquifers capable of supplying the large water volumes required to complete multiple fracture stimulations in horizontal shale gas and shale oil wells, and which also have capacity to safely accept injection of fluids contaminated by drilling and completions operations. Improved knowledge of regional aquifers and their contained waters will also aid in understanding fluid flow and heat flow in the basin, and may assist in the development of geothermal resources.
Project description Timeline: April 1, 2011 – March 31, 2015	Accessing large volumes of water suitable for multi-frac horizontal completions is a problem common to many shale gas and oil developments in North America. Using deep subsurface aquifers for water source and disposal avoids environmental issues arising from withdrawal and possible contamination of surface or shallow subsurface water supplies, and avoids potential conflicts with other water users, such as nearby residents drawing water supplies from shallow water wells. Potential aquifers will be identified from current stratigraphic knowledge, and mapped in the subsurface using oil and gas well data – well logs, cores, sample cuttings, and tests. Gross thickness, net reservoir thickness, and reservoir capacity (porosity-thickness) will be mapped. Outcrop (rock exposure at the surface) measurements may be incorporated where applicable. Core data will be used to characterize porosity / permeability relationships. Test data will be analyzed to determine fluid content and reservoir permeability and continuity. Water analysis data will be screened and summarized to characterize water quality. Project location: Calgary (Alberta) and Yellowknife (NWT)
Summary of key findings	Complete key findings will be disclosed at the project end date (March 31, 2015). Preliminary results might be disclosed prior to this end date. At the present time, there is no basin-scale characterization of appropriate aquifers to support shale gas / shale oil development activities in the Northwest Territories. This project will provide regional knowledge about available aquifers, which will assist both operating companies and regulators in assessing the potential commercial viability of shale gas / shale oil development in new areas. Project results will also guide more detailed characterization required to identify specific aquifer targets, once a shale gas / shale oil development has been undertaken.

Partners	The project is led by Adrienne Jones from the Northwest Territories Geoscience Office (NTGO). Non-NRCan collaborators include Petrel Robertson Consulting
Key contact	Adrienne Jones, Project Leader, Northwest Territories Geoscience Office, Yellowknife, NWT, Phone: (867) 669-2488, email: adrienne_jones@gov.nt.ca

FEDERAL	
Project/Study Title	**Baseline Surface Water Quality of River and Streams in the Petitot River Basin: Examining Potential Impacts of Shale Gas Development in the Horn River Basin, British Columbia**
Project/Study Goal	This project will provide aquatic ecosystem information and knowledge to support policy development, inform stakeholders, and ensure the environmentally responsible development of shale gas resources in Canada, such that threats to Canada's water resources and aquatic ecosystems are minimized and the sustainability of the resource is maintained.
Project description Timeline: April 1, 2012 – March 31, 2016	Potential impacts to surface waters resulting from shale gas activities have been noted elsewhere in North America (e.g. Marcellus Shale deposit, Kargbo et al., 2010 and Soeder and Kappel, 2009). However, little surface water quality monitoring information specific to areas where shale gas extraction is occurring is available at present. In this project baseline water quality information from the riverine environment will contribute to mitigating risks to the aquatic environment in the Petitot River Basin and will serve to advance the growing industry in an environmentally responsible manner. The Project will have monitoring components that include: • Temporal water quality monitoring at three key locations for a standard suite of basic physical-chemical parameters, • Spatial water quality surveillance for a range of contaminants specific to shale gas activities and development in multiple media at key locations during hydrologically significant periods, and • Annual aquatic biological monitoring for ecosystem health and in-situ water quality on the Petitot River mainstem and tributaries. This project will focus on the Petitot River Basin overlying the Horn River Basin (a shale formation) located in north-eastern British Columbia. Activities may extend beyond the Petitot River Basin within the boundaries of other river basins overlying the formation (i.e. Fort Nelson and Hay rivers) in order to capture representative aquatic baseline conditions.
Summary of key findings	Complete key findings will be disclosed at the project end date (March 31, 2016). Preliminary results might be disclosed prior to this end date.
Partners	The project team is led by research scientists from Environment Canada.
Key contact	Bev McNaughton Environment Canada, PY Water Quality Monitoring and Surveillance, Tel: 604 664 4054, e-mail: beverly.mcnaughton@ec.gc.ca

FEDERAL	
Project/Study Title	**Indicators of Impacts of Shale Gas Development on Groundwater**
Project/Study Goal	The projects goal is to develop indicators that can be used to detect groundwater impacts associated with shale gas development and to provide initial assessment of their significance. A secondary goal is to provide improved understanding of the potential impacts of shale gas development in Canada on groundwater.
Project description Timeline: April 1, 2012 – March 31, 2016	This project will produce 'Indicators of Impacts of Shale Gas Development on Groundwater in Canada'. The work on developing these indicators will include three components: • R&D on suitable indicators: Laboratory work, for selection of suitable chemical indicators (tracers) of fracturing fluids and/or fugitive gases. • Piloting of field application of the indicators: Collecting monitoring data at shale gas exploration and/or production sites, and testing various field monitoring / sampling techniques. • Numerical modeling, integrated with the other components: Development and testing of conceptual models using numerical groundwater flow and transport simulations of shale gas exploration and production sites. The indicators developed in this project will be based on: • current conceptual understanding of potential impacts of shale gas development in Canada; • improved understanding of the potential impacts of shale gas development in Canada that results from the lab and field components of this project; • collation of existing relevant information, such as existing reports, publications and monitoring data; and • on sound application of the internationally accepted DPSIR (Drivers, Pressures, State, Impact, Response) approach for development of environmental indicators The project will be carried out in Burlington Ontario, as well as locations of provincial participants, British Columbia, Alberta, New Brunswick, Nova Scotia and others.
Summary of key findings	Complete key findings will be disclosed at the project end date (March 31, 2016). Preliminary results might be disclosed prior to this end date.
Partners	The project team is led by research scientists from Environment Canada. Non Environment Canada collaborators include: • Université Laval

	• Natural Resources Canada • New Brunswick Department of Environment • Nova Scotia Environment • British Columbia Ministry of Energy and Mines • Alberta Environment
Key contact	Dr. Dale Van Stempvoort, Groundwater Quality and Assessment Section, Water Science & Technology Directorate, Environment Canada, dale.vanstempvoort@ec.gc.ca Telephone 905-319-6917

FEDERAL	
Project/Study Title	**Unconventional gas potential from Paleozoic shales of eastern Canada – addressing knowledge gaps for sustainable development**
Project/Study Goal	A modern understanding and appraisal of shale gas entails two major issues: social acceptability and economic pertinence for development. These relate to local and regional water management issues, notably preoccupations about groundwater and geological characteristics of shale gas and overlying cap units. For each issue, it is proposed to first synthesize the available public domain data and second, in part based on the conclusions of the first phase, to develop research initiatives to fill perceived or identified knowledge gaps.
Project description Timeline: April 1, 2011 – March 31, 2015	The issues that will be addressed by this project revolve around three main themes: A) Understanding the hydrogeology of shallow and deep groundwater aquifers; B) Geological characterization of prospective shale gas units and their capping successions and; C) Evaluation of the natural and eventually artificially induced connectivity between the deep gas production zones and the shallow water zones used for water supply. Given the diverse stages of shale gas exploration and development in eastern Canada, the breadth of efforts to be invested in these three themes will vary from one jurisdiction to the other. Project location is in Eastern Canada. Laboratory and office work is based in Québec City, Calgary, Fredericton, Halifax and St. John's
Summary of key findings	Complete key findings will be disclosed at the project end date (March 31, 2015). Preliminary results might be disclosed prior to this end date.
Partners	The project team is led by research scientists from Natural Resources Canada (NRCan) in Québec City and Calgary. Non-NRCan collaborators include: • Québec–Ministère du Développement durable, de l'Environnement et des Parcs • Québec–Ministère des ressources naturelles et de la Faune • New Brunswick–Department of Natural Resources • Nova Scotia–Department of Energy • Newfoundland–Department of Natural Resources • INRS-ETE • University of New Brunswick • Memorial University
Key contact	Denis Lavoie, Research Scientist , Geological Survey of Canada – Québec Office, Québec, Qc , Phone: 418-654-2571, email: delavoie@nrcan.gc.ca

FEDERAL	
Project/Study Title	**Assessment of the potential impacts of shale gas exploration and development activities on groundwater resources**
Project/Study Goal	This project aims to develop tools for assessing the potential impacts on groundwater resources associated with shale gas exploration/ development. These tools would facilitate identification of the areas with the fewest constraints for shale gas development as well as those areas where industry practices will have to be modified in order to minimize the risks to groundwater resources.
Project description Timeline April 1, 2012 – March 31, 2016	This project proposes to conduct a scientific study that will improve knowledge about the potential link between productive shale formations (usually located 2 km or deeper) and surface aquifers (< 200 m), as well as the factors that may contribute to this link. The issues examined are: • understanding the potential impacts of shale gas related activities; and • assessing the exploration and development conditions that could minimize these impacts on groundwater resources. The project is divided into four interrelated components: • conducting a hydrogeological characterization and developing a geological model to identify potential conduits, at the local scale, that contribute to the migration of contaminants; • modeling flow and studying fracture hydraulics; • conducting a geochemical study by sampling water from drilled wells, residential wells and deep wells; and • assessing the impacts associated with aquifer vulnerability. The site selected for the study is the Appalachian foothills, in east Montérégie, Québec, where abundant Ordovician faults are well known (e.g. Logan's Line, Saint-Barnabé Fault, Aston Fault); this region is currently in the active shale gas exploration area.
Summary of key findings	Complete key findings will be disclosed at the project end date (March 31, 2016). Preliminary results might be disclosed prior to this end date.
Partners	The research team is headed by Dr. Christine Rivard of the Geological Survey of Canada. Other research scientists from the Geological Survey of Canada in Ottawa and Québec City are also involved in this project. Environment Canada is a collaborator.
Key contact	Christine Rivard, Hydrogeology Research Scientist Geological Survey of Canada (GSC-Québec), Québec City, QC Telephone: (418) 654-3173, e-mail: crivard@nrcan.gc.ca

FEDERAL	
Project/Study Title	**Development of Shale Gas Monitoring Technology**
Project/Study Goal	The project seeks to develop tracer technology that will enable reliable and unambiguous detection of leakage of natural gas and/or fracturing (frac) fluids from hydraulically fractured shale gas fields. A universally applicable monitoring system for the tracer(s) will be developed.
Project description Timeline: April 1, 2012 – March 31, 2016	The objectives of the project are to: • Identify an effective tracer to unambiguously detect natural gas and fracture fluid leakage from hydraulically fractured shale gas fields. • Assess, and develop if required, surface monitoring tracer technologies and protocols. • Develop tracer injection strategies for best performance of the tracer. The Project will: • Conduct literature review and desktop study to identify potential tracer candidates; • Development of lab testing program to determine properties and performance of tracers under actual operating conditions; • Completion of laboratory testing of tracers and performance comparison; selection of most suitable candidate(s); • Numerical simulation of injection and migration of tracer; results will inform development of detection methods and injection strategies; • Development of universally applicable monitoring system and development of tracer injection strategies. The Project will be located in Ottawa, Ontario.
Summary of key findings	Complete key findings will be disclosed at the project end date (March 31, 2016). Preliminary results might be disclosed prior to this end date.
Partners	The project team is led by research scientists from Natural Resources Canada (NRCan) CanmetENERGY-Ottawa. Non NRCan Collaborators include: • Petroleum Technology Research Centre (PTRC) • HTC Pure Energy
Key contact	David Ryan, NRCan, IETS, CanmetENERGY-Ottawa, (613) 996-3179, dryan@nrcan.gc.ca

FEDERAL	
Project/Study Title	**A Study of Potential Links Between Shale Gas "Fracking" and Induced Seismicity for Sustainable Development and Improved Regulatory Performance**
Project/Study Goal	The main purpose of this project is to address a key knowledge gap between the practice of "fracking" by the oil and gas industry and the possibility of induced earthquakes in major shale gas basins across Canada. This project will focus on (1) the establishment of sound scientific observations upon which any potential links between the practice of fracking and induced earthquakes, if exist, can be assessed and studied in detail, and (2) a systematic evaluation of major shale gas basins to quantitatively characterize the likelihood of large/major earthquakes being induced by fracking.
Project description Timeline: April 1, 2012 – March 31, 2016	The main objectives of this project are to provide observation-based conclusions on the following key questions: • Can the practice of fracking alter the local, or even regional pattern of background seismicity? • What is the relationship, if exists, between how fracking is performed and the maximum magnitude of induced earthquakes? • What is the time scale of the interaction between fracking events and induced seismicity? • And are there clear scientific evidences, from a seismic hazard's point of view, to suggest imposing different fracking regulations for shale gas basins under different tectonic/geological conditions? The project has 4 major research components: • Improving monitoring capability of the spatiotemporal distribution of earthquakes for major shale gas sites; • Comprehensive analysis of seismic records for induced earthquakes; • Quantitative assessment of the overall seismogenic stress state for major shale gas basins; • Geomechanical modelling of the stress transfer effect due to fracking. Field, laboratory and office work will take place in British Columbia, Québec and New Brunswick.
Summary of key findings	Complete key findings will be disclosed at the project end date (March 31, 2016). Preliminary results might be disclosed prior to this end date.
Partners	The project team is led by research scientists from Natural Resources Canada (NRCan) in Ottawa, Québec and British Columbia. Non-NRCan collaborators include the British Columbia Oil and Gas Commission.
Key contact	Honn Kao, Research Scientist, Geological Survey of Canada (Natural Resources Canada, Sidney, British Columbia, Phone: (250) 363-6625, email: hkao@nrcan.gc.ca

FEDERAL	
Project/Study Title	**Investigation of Enhanced Shale Gas Production Techniques**
Project/Study Goal	The objective of the project is to investigate the potential use of CO2 (and other potential fluids) for enhanced production of methane from shale gas formations. CO2 is widely used in conventional oil and gas production operations, also known as enhanced oil recovery (EOR) or enhance gas recovery (EGR) operations and has been tremendously successful. CO2 injection into coals to enhance methane production has also been tried in North America and internationally with mixed results of success.
Project description Timeline: April 1, 2011 – March 31, 2015	This project intends to look at the use of CO2 for enhanced shale gas production and sequestration of CO2 after the shale gas is depleted. Significant issues/problems with shale gas plays are recovery of resource in place, economics, and environmental footprint. There is a need to improve the recovery rate of methane from target shale gas reservoirs. The project will investigate the potential use of enhanced methods for shale gas production and the implications this could have on economics and environment for shale gas production. Tasks include: • The first step will be an overall evaluation based on available data and literature in this area (year 1). • In year 2, the work progress to and involve gathering geological data for targeted specific shale gas reservoirs, shale description/characterization information, and looking at potential sources of CO2 at or near the production reservoir and an evaluation of the gaps in knowledge. • Year 3 will then investigate in further detail. • Year 4 will include further analysis on the economics and environmental impacts of shale gas production, with special focus on comparison of conventional production technologies and the shale-gas production combined with CCS. The project will terminate with a final report on the findings of the project and recommendations for further study. Project location: CanmetENERGY Ottawa – Bell's Corners Complex
Summary of key findings	Complete key findings will be disclosed at the project end date (March 31, 2015). Preliminary results might be disclosed prior to this end date.
Partners	The project team is led by research scientists from Natural Resources Canada (CanmetENERGY) in Ottawa.
Key contact	David Ryan, NRCan, IETS, CanmetENERGY-Ottawa, (613) 996-3179, dryan@nrcan.gc.ca

FEDERAL	
Project/Study Title	**The Addition of Unconventional Natural Gas Supply to GHGenius**
Project/Study Goal	To modify the natural gas pathways in GHGenius to accommodate different sources of natural gas, including shale gas; recognizing that compared to conventional gas, the GHG emission profiles from several other sources of gas are likely to be significantly different.
Project description Timeline: Report completed in March, 2010	GHGenius is capable of estimating life cycle emissions of the primary GHGs and criteria air pollutants from a wide range of combustion and process sources. Previously the data on natural gas production in the mode was based on a weighted average of solution gas, non-associated, and tight gas. With the modifications, the use of the model can now choose each type of natural gas individually. The proportion of each type of gas to the national gas pool in the model was based on National Energy Board data and forecasts through to the year 2020. The different life-cycle emissions associated with natural gas supply included: fuel distribution and storage, fuel production, feedstock recovery, gas leaks and flares and CO2/H2S removal, and the emissions from the combustion of natural gas.
Summary of key findings	Overall lifecyle greenhouse gas emissions from shale gas produced in Canada are on average 4 percent greater than conventional natural gas (and no difference if comparing unconventional 'tight' gas to conventional gas).
Partners	The project and report was commissioned by Natural Resources Canada, Office of Energy Efficiency.

BRITISH COLUMBIA	
Project/Study Title	**Hydraulic Fracture Water Usage in Northeast British Columbia: Locations, Volumes and Trends**
Project/Study Goal	The purpose of this report is to gain an understanding on the aspects of multistage hydraulic fracturing that most affect water consumption and the location and extent to which they are being employed.
Project description Timeline: Iterative (2009, 2010, 2012)	The main objectives of this project are to provide observation-based conclusions on the following key questions: • What is the average and maximum volume of water used per well? What trends can be detected? • What is driving water usage and trends? Is it technological capability, access to water or better engineering for the target shale? • How much water is returned to surface for potential reuse? The project focused on five regions in northeastern British Columbia where water use is predominantly from wells with multiple fractures (Horn River Basin, Montney and Montney North Play Trend, Deep Basin, and the Southern Foothills). Data from 500 wells was analyzed for relationships (both over time and by region) between hydraulic fracturing water usage and: • fracture intensity (fracture per well, horizontal length fractured and fracture spacing), • type of fracturing (energized, slickwater or hybrid) • water use intensity (volume per fracture) • geology of the target formation • value of water use (gas productivity relative to water injected) • water return for reuse
Summary of key findings	• Findings show water usage varied by basin with strong differences originating from the stimulation treatment method used. • In general, a basin's geology determines fracture treatment. High-volume water use is not limited to multistage fracturing of brittle shale in the Horn River Basin; it is also used to develop sandstone and conglomerate in the Deep Basin south of Dawson Creek. • Even a small number of slickwater wells can substantially alter the cumulative water usage in a basin far more than a large number of energized wells. Increased stimulation volume greatly increased the estimated ultimate recovery from slickwater wells in the Muskwa–Otter Park shales in the Horn River Basin which is driving water demand in the basin.
Partners	The project team was led by a research scientist from British Columbia Ministry of Energy Mines and Natural Gas Natural Resources with support from a consulting research scientist.

Key contact	Elizabeth Johnson, Senior Hydrogeologist, Geoscience and Strategic Initiatives Branch, Oil and Gas Division, Ministry of Energy, Mines and Natural Gas, Victoria, British Columbia, Phone: (250) 952-0418, Email: Elizabeth.Johnson@gov.bc.ca

BRITISH COLUMBIA	
Project/Study Title	**Flaring, Venting and Incinerating Summary**
Project/Study Goal	Annual summary of flared volumes of gas and progress toward meeting the objectives of reducing or eliminating flaring, venting and incinerating as outlined in the British Columbia Energy Plan.
Project description Timeline: Jan.-Dec. 2011	The British Columbia Oil and Gas Commission works with operators to ensure all flaring, venting and incinerating reduction options are considered, including elimination, reduction where elimination is not possible (for instance, if there is a lack of available infrastructure such as pipelines and facilities in the vicinity due to remoteness of the activity), and improvement of the efficiency of flare, vent and incinerator systems.
Summary of key findings	• 36 per cent decrease in flaring levels since 1996; 22.3 per cent decrease in flaring levels since 2006; 97 per cent conservation of solution gas in 2011. • A five per cent decrease in solution gas flaring since 2010, and a 93.1 per cent decrease since 1997. • A 3.2 per cent decrease in well cleanup and well test flaring since 2010. • A 9.3 per cent decrease in flaring from underbalanced drilling from 2010 to 2011. • From 1996 to 2011, natural gas production increased by 76 per cent and the amount of gas flared per unit of natural gas production decreased by 63 per cent. • The total gas flared per unit of production in 2011 was 4.9 m3/1,000 m3, which is below the forecasted amount of 5.4 m3/1,000 m3 in the Commission's 2011/12 Service Plan.
Partners	British Columbia Oil and Gas Commission
Key contact (s)	Kevin Parsonage, Supervisor, Field Engineering & Technical Investigations, 250-419-4400

BRITISH COLUMBIA	
Project/Study Title	Investigation of Observed Seismicity in the Horn River Basin
Project/Study Goal	Cause of anomalous seismic activity near oil and gas activities.
Project description Timeline: July 2011 – August 2012	The main objective of this project was to address the following key question within the geographically confined and remote areas of the Horn River Basin in northeast British Columbia: • Was hydraulic fracturing the cause of the low level seismic activity (between April 2009 and December 2011)? Data was obtained from numerous sources including open source information as well as proprietary data acquired by oil and gas companies working near the area of the investigation.
Summary of key findings	1. The seismicity observed and reported by Natural Resources Canada (NRCan) in the Horn River Basin between April 2009 and December 2011 was induced by fault movement resulting from injection of fluids during hydraulic fracturing. 2. No injuries or property damage were reported as a result of the induced seismicity. Only one event was reported by NRCan to have been felt at the ground surface. 3. The fractures developed during the hydraulic fracturing operations studied within the investigation were effectively confined to the target Horn River shales by the overlying Ft. Simpson shales. No effects on shallow aquifers or the environment were identified. 4. The magnitude and frequency of the induced seismicity investigated by the Commission may be influenced by numerous factors including pump rate, breakdown pressure and proximity to pre-existing faults. 5. No casing deformation was reported in the vertical portion of wellbores and no reservoir containment issues were identified. Minor casing deformation within the horizontal well portion of target shale formations occurred in 2 instances. The cause of the casing deformation could not be conclusively linked to the seismicity. 6. Fault mapping provided by operators shows abundant sub parallel north-south trending faulting through the Etsho and Tattoo areas. These faults are generally deep seated and do not show displacement above the Ft. Simpson shale. The Ft. Simpson shale is considered to be a ductile fracture barrier.

	Fault reactivation in this structural setting is not considered a threat to shallow overlying aquifers. 7. Seismograph station additions are needed to the CNSN to improve monitoring for induced seismicity in northeast British Columbia.
Partners	The investigation was completed by the British Columbia Oil and Gas Commission's geological and engineering staff within the Resource Development department, and they benefited from consultation with NRCan, the University of British Columbia and the Alberta Geological Survey.
Key contact (s)	Dan Walker, Senior Petroleum Geologist, British Columbia Oil and Gas Commission, 250-419-4400

BRITISH COLUMBIA	
Project/Study Title	**Oil and Gas Land Use in the Fort Nelson LRMP area of British Columbia**
Project/Study Goal	This report is produced by the British Columbia Oil and Gas Commission (Commission) to provide government, industry, First Nations and stakeholders with an understanding of the surface area used to date by oil and gas activities in the Fort Nelson Land and Resource Management Plan (FNLRMP) area and a description of the methodology used to calculate the areas by activity. Goals include enhanced stewardship and reduced social and environmental impacts.
Project description Timeline: Up to and including January 2013 for the FNLRMP area	The Commission identified a need for a standardized methodology for the measurement of surface disturbances caused by oil and gas activity. The Commission will build on measurement standards to calculate the changes in surface area used by oil and gas activity going forward. The report focuses on two aspects of oil and gas activity in the FNLRMP area in addressing the question of the footprint of the oil and gas industry in northeast British Columbia.: • The type of surface activity • The surface area used by each activity
Summary of key findings	The report provides an overview of surface land use by well sites, pipelines, roads, geophysical exploration programs, facilities and associated oil and gas activities up to and including January 2013 for the FNLRMP area. Key findings include: • The analysis indicated oil and gas activity is a small per cent of the overall disturbance in the Fort Nelson Land and Resource Management Plan area. • Of the oil and gas disturbance, historic seismic disturbance was the largest contributor, but with modern low-impact seismic methods, it is expected that contribution will drop significantly. • Standardized methodology for the measurement of surface disturbances caused by oil and gas activity. • Explains the methodology used to collect data, sources, assumptions and limitations and how the Commission is actively working to improve future statistical reporting. • Given the known data limitations, the Commission's methodology errs on the side of a larger number of surface disturbances than may actually exist. For example, Terrain Resource Information Management Program II (TRIM II) data, which is largely based on the interpretation of older aerial photographs, likely overestimates the number of seismic lines in the FNLRMP. To reduce this error, the

	Commission has used a preliminary sampling method to identify seismic lines versus other linear features such as roads; however, vegetation regrowth that has restored ecological function to old seismic lines has not been factored into the calculations presented. • The Fort Nelson Land and Resource Management Plan encompasses approximately 9.8 million hectares of Crown land . • The Commission calculated the surface footprint resulting from the following disturbances: • Seismic lines (resulting from geophysical exploration); • Roads; • Wells; • Pipelines; • Facilities; • Other oil and gas Infrastructure (such as camps).
Partners	British Columbia Oil and Gas Commission
Key contact (s)	Sean Curry, Manager, Resource Development, British Columbia Oil and Gas Commission, 250-419-4420

ALBERTA	
Project/Study Title	**Groundwater Observation Well Network**
Project/Study Goal	The Groundwater Observation Well Network (GOWN) is an Alberta Environment owned network of groundwater monitoring wells located in various aquifers throughout the province. Most of these wells are fitted with specialized electronic equipment that continually record groundwater levels. In addition, many of these wells are pumped and sampled for water quality analysis.
Project description Timeline:	Alberta Water Well Information Database (AWWID) Ongoing, new wells being added.
Summary of key findings	The Alberta Research Council started the network in 1957 with three wells in Drayton Valley, Leduc and Milk River. In 1982 the network was transferred to Alberta Environment which had expanded to 145 wells. At that time there were 55 wells distributed around the province for general groundwater level monitoring along with 90 wells for monitoring groundwater levels and quality in the oil sands region around Fort McMurray. The network has since expanded for better provincial coverage. Today there are over 250 GOWN wells, with about 200 wells being monitored for levels and 160 wells for quality. Water Well Drilling Reports: This dataset contains the drilling reports for over 500,000 water wells, flowing shot holes and test holes. The dataset may include pump tests, lithologies and water chemistries for these reports. Baseline Water Well Test (BWWT) Reports: This dataset contains water well test reports collected by the department under ERCB Directive 35: Baseline Water Well Testing Requirement for Coalbed Methane Wells Completed Above the Base of Groundwater Protection. The dataset may include pump tests, water chemistries and produced gas analysis. The Baseline Water Well Testing Requirement is currently under review for expansion to include hydraulic fracturing.
Partners	N/A
Key contact (s)	If you require further information please contact Alberta Environment and Sustainable Resource Development's Groundwater Information Centre (GIC) by email at gwinfo@gov.ab.ca, fax (780) 427-1214 or phone (780) 427-2770.

ALBERTA	
Project/Study Title	**Alberta Microseismicity Project**
Project/Study Goal	The Alberta Microseismicity Project is part of the Geohazards Program. The goal is to monitor natural and induced seismicity to compile a comprehensive earthquake catalogue of Alberta. An earthquake catalogue (seismic database) will help to understand the natural seismicity patterns and recognize unusual patterns from anthropogenic activities. Alberta will also produce a baseline of natural seismicity to detect unusual seismic activity in the future.
Project description Timeline:	Monitoring, data collection and analysis Started in 2009
Summary of key findings	Most of the earthquakes that occur in Alberta are very small. These are termed microearthquakes, which are less than 3 local magnitude (ML). Although these earthquakes are typically not felt, the information contained within the events is important to our understanding of the processes that may have a potential to trigger earthquakes.
Partners	University of Alberta, University of Calgary, Geological Survey of Canada in Canada, and data from seismic stations owned and operated by the Montana Bureau of Mines and Geology and U.S. Geological Survey.

QUÉBEC	
Project/Study Title	**Développement durable de l'industrie des gaz de schiste au Québec – Rapport d'enquête et d'audience publique (Sustainable development of the shale gas industry in Québec – Inquiry and public hearing report)**
Project/Study Goal	The Québec Bureau d'audiences publiques sur l'environnement (BAPE) was mandated to set up a commission of inquiry on the sustainable development of the shale gas industry in Québec and to hold consultations in the administrative regions of Centre-du-Québec, Chaudière-Appalaches and Montérégie.
Project description Timeline: September 2010 – February 2011	The BAPE commission of inquiry was tasked to: - recommend a shale gas exploration and development framework that would promote harmonious coexistence of these activities with local communities, the environment and other activities in the area; - formulate guidelines for a legal and regulatory framework that will ensure, for the natural gas exploration, development and collection infrastructure components, the safe development of this industry in a manner compatible with sustainable development objectives; - assess all issues related to this mandate with the assistance of scientific experts. The BAPE's report is subdivided into three parts: - The first part presents the commission of inquiry's approach, provides a factual description of the receiving environment, the shale gas industry, the phases of development as well as the concerns and opinions expressed by participants. - The second part consists of an analysis of the issues and covers water use and protection, air quality, the risks associated with this industrial activity, the human environment and the economy. - The third part formulates guidelines for the safe development of the industry in a manner compatible with sustainable development objectives while ensuring harmonious coexistence of industry activities with local communities, the environment and other activities in the area. Public consultations were held in various municipalities located in the administrative regions of Centre-du-Québec, Chaudière-Appalaches and Montérégie. Field visits were conducted in Alberta, British Colombia, Texas, Pennsylvania and New York State.
Summary of key findings	The missions and field visits carried out also provided a better understanding of the context in which the eventual exploration and development of shale gas in Québec will take place. However, there were only partial or no answers to certain basic questions. To meet this need for more detailed scientific knowledge and in the

	absence of evidence that would make it possible to determine the potential risks of shale gas exploration and development, it was recommended that a strategic environmental assessment be conducted. While this assessment is under way, hydraulic fracturing (fracking) will be permitted only for the work required by the assessment. Exploration work may continue, but without the use of fracking. This type of assessment is indispensable both to ensure an informed decision-making process and increase the social acceptability of this activity.
Partners	Bureau d'audiences publiques sur l'environnement du Québec / Government of Québec
Key contact	Bureau d'audiences publiques sur l'environnement (www.bape.gouv.qc.ca), Telephone: 418-643-7447 or 1-800-463-4732

QUÉBEC	
Project/Study Title	**Élaboration de différents scénarios de gestion des eaux de reflux et évaluation de leurs coûts (Development of various flowback water management scenarios and cost estimates)**
Project/Study Goal	The goal of the strategic environmental assessment (SEA) on shale gas is to understand and document the environmental, economic and social impacts of the development of the gas potential in Québec. In the context of its activity plan, the SEA Committee recommended that the following study be conducted: Development of various flowback water management scenarios and cost estimates.
Project description Timeline: 2011 – December 2012	This study was conducted by the Industrial Water Section and the Municipal Water Section of the Water Policy Branch of the Québec Department of Sustainable Development, Environment, Wildlife and Parks in the context of the strategic environmental assessment (SEA). The SEA Committee recommended that this study examine the development of various flowback water management scenarios and cost estimates based on the level of production and quality of flowback water, potential re-use of this water, flowback water handling and waste disposal. The study mainly examined three flowback water management scenarios. The report also considered the levels of production and quality of flowback water, potential re-use of flowback water, flowback water handling (on-site holding ponds or tanks, municipal wastewater treatment plants) and waste disposal.
Summary of key findings	In order to minimize water withdrawals and preserve the resource, the study authors recommended re-use of the flowback water generated by the shale gas industry. Moreover, the ability of municipal wastewater treatment plants (MWTP) to receive and treat wastewater from the gas industry is limited. The use of MWTP as a wastewater disposal method would not be a feasible option in a context of large-scale development of the gas industry, generating significant volumes of wastewater. Consequently, in a context of development of the shale gas industry, most of the wastewater generated by this industry would have to be treated on site or at facilities designed for this purpose. All discharges of treated flowback water into the receiving environment will thus have to comply with government-mandated standards and requirements. If conditions suitable for the injection of wastewater into deep geological formations are identified for Québec, this disposal method could also be considered.
Partners	Québec Department of Sustainable Development, Environment, Wildlife and Parks – Industrial Water Section and Municipal Water Section of the Water Policy Branch (Government of Québec)
Key contact	Québec Department of Sustainable Development, Environment, Wildlife and Parks – Industrial Water Section and Municipal Water Section of the Water Policy Branch Service (Government of Québec)

NEW BRUNSWICK	
Project/Study Title	**New Brunswick Shale Gas Air Quality Impacts Study**
Project/Study goal	The New Brunswick Department of Environment and Local Government (DELG) and Health Canada have identified a need to understand the potential impact that shale gas development may have on air quality in regions where such development may occur. The two agencies have therefore agreed to jointly undertake a project to monitor air quality impacts from selected phases of shale gas operations including baseline values (prior to development and during drilling), well completion (e.g. hydraulic fracturing, flowback), and natural gas recovery.
Project description Timeline: An interim report is intended by the end of 2013-2014 fiscal year, with a final report expected during the 2015-2016 fiscal year. However, delays may occur based on site availability and other factors.	The study consists of four parts to address the question of what effect do shale development activities have on local air quality: • Part I – Baseline: Air quality data will be gathered at a control site. For the purposes of this study, a control site has been selected in a potential shale gas development area that is not currently being impacted by shale gas development. The site will be located in the general area of Apohaqui, along Route 880, north of Route 121. Baseline data (for the parameter listed further below), will be collected for one year, and will serve as a point of comparison for the data collected in other parts of the study. A full year of monitoring is required in order to account for natural seasonal variations in ambient contaminant levels. • Part II – Active Well: - Monitoring will be conducted near a shale gas development site. Ideally, the site will be identified and monitoring will be initiated prior to well pad development. If this is not possible, an existing site will be selected. Monitoring of the study parameters will be conducted at 9 locations surrounding the facility, forming an inner and outer ring of monitoring stations. A station will also be located at the nearest downwind populated area. The objective is to characterize air emission impacts from site development, hydraulic fracturing, and gas production. • Part III - Gas Plant: Monitoring at the gas plant site will be conducted over a 4 to 6 week period. Eight locations will be monitored at the gas plant site, with a setup similar to that described above in Part II (8 stations forming inner and outer rings). • Part IV - Decommissioned Well: There are two locations in New Brunswick where hydraulic fracturing has occurred and the wells were subsequently decommissioned. Selection of one site is to be determined. The monitor configuration and timeframe will be similar to the arrangement for the gas plant in Part III. If preliminary data suggest modifications to refine the monitoring, the necessary changes will be considered by the investigators. The following

	parameters will be monitored:
	• Wind Speed
	• Wind Direction
	• Sulphur dioxide
	• Total Reduced Sulphur
	• Carbon monoxide
	• Nitrogen oxides (NO2/NOX)
	• Particulate Matter:
	  ○ PM2.5
	  ○ Filter-based (FRM) particulate
	  ○ PM metals analysis
	  ○ PM Chemical Speciation
	• Ozone
	• Volatile Organic Compounds (VOC)
	  ○ Summa canister-based sampling of the full suite of VOCs every 6 days.
	  ○ Passive VOC samplers
	• Semi Volatile Organic Compounds (SVOC) (includes dioxins, furans, and polycyclic aromatic hydrocarbons)
	  ○ Filter based - every 12 days.
	• Carbonyl Compounds (e.g., formaldehyde, acetaldehyde, and hexanal)
	  ○ Summa canister-based sampling of carbonyl compounds every 6 days.
	
	Also, one monitoring station will be outfitted for continuous real-time monitoring of the BTEX (benzene, toluene, ethylbenzene, and xylene) range VOCs and methane during Parts I and II of the study.

Summary of key findings	Health Canada, in collaboration with the New Brunswick Department of Environment and Local Government, will report on the findings.
Partners	Partners include New Brunswick Department of Environment and Local Government / Health Canada

D) Public Awareness, Engagement and Disclosure

BRITISH COLUMBIA	
Initiative Title	FracFocus.ca
Initiative goal	FracFocus.ca is a registry that provides a transparent accounting of hydraulic fracturing operations. It includes a database of the ingredients used to support natural gas extraction, and extensive content about the regulations and safety procedures governing industry activity.
Initiative description Timeline: Effective January 1, 2012	British Columbia was the first province in Canada to require the mandatory disclosure of ingredients used for hydraulic fracturing. On January 1, 2012, public disclosure for hydraulic fracturing fluid became mandatory in British Columbia. By law, a list of ingredients used must be uploaded to the registry within 30 days of finishing completion operations - the point in time when a well is able to produce gas. Hydraulic fracturing is subject to strict regulations in British Columbia. The Province has instituted laws to ensure the process protects groundwater and the environment. There has never been a documented case of groundwater contamination from hydraulic fracturing within British Columbia. The British Columbia Oil and Gas Commission built FracFocus.ca to accommodate future participation by other jurisdictions so there can be one national site for disclosure information.
Partners	On December 31, 2012, Alberta joined British Columbia in requiring the disclosure of hydraulic fracturing fluids on FracFocus.ca.

BRITISH COLUMBIA	
Initiative Title	**Reporting on Oil and Gas Site Restoration Summary**
Initiative goal	To provide an annual overview of the British Columbia Oil and Gas Commission's Certificate of Restoration program – in northeast British Columbia
Initiative description Timeline: Annual Report	The British Columbia Oil and Gas Commission (Commission) is responsible for overseeing restoration and issuing Certificates of Restoration when appropriate, ensuring restoration activities are completed in the public interest with regard to environmental, economic and social effects.
Summary of key findings	The annual site restoration report provides an overview of British Columbia's Certificate of Restoration program. Statistics on performance measures provide comparisons and benchmarks regarding oil and gas site restoration and are reviewed for effectiveness. Three key measures have been developed and are reported annually. These measures are liability management, application quality and Commission timeliness.
Partners	British Columbia Oil and Gas Commission
Key contact	Devin Scheck, Director, Environmental Management and Reclamation, British Columbia Oil and Gas Commission – 250-419-4400

<table>
<tr><th colspan="2">BRITISH COLUMBIA</th></tr>
<tr><td>Initiative Title</td><td>Reporting on Short-term Water Approvals</td></tr>
<tr><td>Initiative goal</td><td>Annual report to categorize the amount of water permitted/licenced for oil and gas industry use, the amount actually used and it’s relation to the availability of water – northeastern British Columbia.</td></tr>
<tr><td>Initiative description

Timeline:
Annual Report</td><td>Key question to address is whether there is an adequate supply of water to meet the oil and gas industry needs?

Eeport contains short-term water use data for the calendar year, including the cumulative volume of water approved for use and the volume reported as actually used by permit holders. It also includes data on water licences in northeast British Columbia, which are valid for periods greater than one year and under the issuing authority of the Ministry of Forests, Lands and Natural Resource Operations (FLNRO). New to the 2012 report is the inclusion of water volumes used in hydraulic fracturing.</td></tr>
<tr><td>Summary of key findings</td><td>In 2012 the total volume of water approved for withdrawal fell 25 per cent during 2012 to a total of 20.4 million metres (m3) as of the fourth quarter. The total volume of water reported as used was 3,770,019 m3 (18.5 per cent of the approved volume). Water usage in 2012 was comparable to the 2011 volume of 3,673,378 m3.

The basins with the largest total approved volumes as a percentage of mean annual runoff during the last quarter of 2012 are represented in Table 2. For all the remaining basins, the approved short-term water use corresponded to less than 0.20 per cent of mean annual runoff. Actual water use as reported by the approval holders in individual basins is a small fraction of the approved water use, and was less than 0.075 per cent of mean annual runoff in all river basins between January and December 2012.

Table 2: Basins with largest total approved percentage of mean annual runoff
<table>
<tr><td>Lower Halfway River</td><td>1.28</td></tr>
<tr><td>East Kiskatinaw River</td><td>0.72</td></tr>
<tr><td>Lower Pine River</td><td>0.38</td></tr>
<tr><td>Kyklo River</td><td>0.33</td></tr>
<tr><td>Lower Kiskatinaw River</td><td>0.27</td></tr>
<tr><td>Cameron River</td><td>0.26</td></tr>
<tr><td>Kiwigana River</td><td>0.24</td></tr>
<tr><td>Blueberry River</td><td>0.24</td></tr>
<tr><td>Middle Petitot River</td><td>0.23</td></tr>
<tr><td>Capot-Bianc River</td><td>0.23</td></tr>
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	The amount of water used for hydraulic fracturing varies considerably across northeast British Columbia, with the lowest use per well in the Heritage Basin of the Montney Play (south of the Peace River) and the highest use in the Horn River Basin. The varying water requirements are largely dependent on the geology of the formation being fractured. In 2012, a total of 7,054,704 m3 of water was used for hydraulic fracturing. The average water use was 6,670 m3/well (193 wells) in the Heritage Basin, 9,792 m3/well (138 wells) in the north Montney, and 76,923 m3/well (50 wells) in the Horn River Basin. The watersheds with the highest total volumes of water used for hydraulic fracturing are in the Horn River Basin. The total volume of water used for hydraulic fracturing from the Fort Nelson River (Middle Fort Nelson and Kiwigana rivers) was 2,299,257 m3, and from the Petitot River (Lower Petitot, Sahdoanah, Tsea and Upper Petitot rivers) the total water used was 2,156,636 m3.
Partners	British Columbia Oil and Gas Commission
Key contact	Allan Chapman, Hydrologist, British Columbia Oil and Gas Commission, 250-419-4420

BRITISH COLUMBIA	
Initiative Title	**Oil and Gas Resource Management Public Opinion Survey**
Initiative goal	The purpose of the survey was to gather information about British Columbians' opinions and beliefs about the exploration, development, regulation, and management of oil and gas resources within the province.
Initiative description Timeline: Final Report in 2012	This report summarizes responses received from four regions of British Columbia: Vancouver Island/Lower Mainland (Development Regions 1 & 2), Coastal British Columbia (Development Region 6), Southeastern British Columbia (Development Regions 3 & 4), and Central-Northern British Columbia (Development Regions 5, 7 & 8). The survey instrument was a twelve-page booklet that contained questions that comprehensively measured people's attitudes and beliefs about a wide range of issues and challenges regarding the exploration, development, regulation, and management of oil and gas resources in British Columbia. Fourteen questions that made up the survey were: **Question 1:** Opinions and beliefs about the management of oil and gas resources in British Columbia; **Question 2:** Opinions and beliefs about how people relate to the environment; **Question 3:** Previous involvement in natural resource management decision-making through public participation opportunities; **Question 4:** Opinions about the relative priorities for sustaining natural resource values; **Question 5:** Opinions about the trustworthiness of different sources of information about oil and gas development; **Question 6:** Opinions about the safety of oil and gas development in British Columbia; **Question 7:** Opinions about the importance of local ecological, economic, and social management objectives for oil and gas development; **Question 8:** Opinions about local oil and gas development issues; **Question 9:** Opinions about the management of rare plants and animals (*i.e.*, species at risk); **Question 10:** Attitudes and opinions about climate change; **Question 11:** Knowledge about different aspects of oil and gas in British Columbia; **Question 12:** Participation in outdoor recreation; **Question 13:** Opinions about the economic contribution of oil and gas in British Columbia; and **Question 14:** Demographics.
Summary of key findings	Oil and gas resources are generally seen as important and relevant to British Columbians. Although there are some aspects of oil and gas exploration and development that respondents admitted to being uncertain about, respondents from all sample regions were generally aware and

	knowledgeable about many aspects of the management of oil and gas resources. There is a strong sense that the public has a desire to provide input into oil and gas resource management decision-making through public involvement mechanisms and opportunities for communication with local oil and gas managers. Respondents tended to hold pro-environmental views and attitudes. However, there was also a sense that limits to growth were not absolute, and that human ingenuity and technological improvements could serve to provide solutions to many environmental issues. As the vast majority of the ecological, social, and economic objectives presented in the questionnaire were important to respondents, it would seem that an approach that addressed these objectives would be suitable for achieving the sustainable management of oil and gas resources, and that these resonate with the public and are in-line with public opinion of what oil and gas resource management objectives are important. Trust and safety issues are of particular concern for British Columbians. An appetite was found for information about the management of oil and gas resources, particularly to help people be more comfortable participating in decision-making about oil and gas management. Overall, the following priorities for sustaining natural resource values were identified by provincial residents: 1. Sustaining clean drinking water resources. 2. Sustaining biological richness. 3. Sustaining opportunities for a wide range of quality of life values. 4. Minimizing the amount of water used to retrieve oil and gas from the ground. 5. Sustaining economic benefits from other industries (e.g., agriculture, forestry, mining). 6. Sustaining local job creation. 7. Sustaining benefits that First Nations receive from oil and gas exploration and development.
Partners	University of British Columbia; British Columbia Oil and Gas Commission; Science and Community Knowledge Fund
Key contact	Dr. Harshaw, Faculty of Forestry, University of British Columbia

BRITISH COLUMBIA	
Initiative Title	**British Columbia Oil & Gas Exploration Activity Report 2005**
Initiative goal	To assess the state of exploration and development in northeast British Columbia (conventional and unconventional) and to highlight where oil and gas industry activity was occurring in the province in 2005.
Initiative description Timeline: Released in 2006 for reporting on activity in 2005	Exploration and development activity highlights in 2005 are covered for six resource regions in northeast British Columbia: Laird Basin and Fold Belt; Fort Nelson/Northern Plains; Fort St. John; Deep Basin; Northern Foothills; and the Southern Foothills. The project also reported on field activity carried out in the Nazko and Redstone areas of the Nechako Basin and in the Chilcotin Ranges. Field activities were also carried out in the southern Bowser and Sustut basins to gain a better understanding of the hydrocarbon potential Key question included: • Where were the petroleum and natural gas right sold in the province in 2005? • Who are the producers and in what areas are they operating in northeast British Columbia's resource regions? • How successful are these producers in their respective areas of operations? • Where are the new potential areas for growth for natural gas in British Columbia? (e.g. prospects for further development) • What were the latest projects in the Nechako Basin (interior basins)? • Was there industry activity for coalbed gas development in northeast and southeast British Columbia? Land sale activity, industry activity and the latest production numbers are covered for each of northeast British Columbia's oil and gas resource regions, including the Interior Basins and southeastern British Columbia
Summary of key findings	• Industry activity in the province was vigourous in 2005. • Drilling activity in British Columbia reached the second highest level ever recorded at 1,429 wells drilled. • Some activity was recorded in the southeastern British Columbia, centering on coalbed gas exploration. • Raw natural gas production reached over three billion cubic feet (Bcf) per day and conventional oil production was 31,000 barrels per day. • In 2005, the British Columbia Oil and Gas Commission issued 1,790 well licences representing the highest annual level of well licences issued in the province. • Strong commodity prices continue to give producers the incentive to increase spending on new exploration projects, but the cost of adding reserves for Canadian and independent US producers is high.

	• New permits for drilling in British Columbia have been on the rise for the past four years. • The British Columbia Ministry of Energy, Mines and Petroleum Resources , in collaboration with the National Energy Board , completed a review of the undiscovered natural gas resource potential for northeastern British Columbia.
Partners	British Columbia Ministry of Energy, Mines and Natural Gas, Oil and Gas Division, Geoscience and Strategic Initiatives Branch
Key contact	Christopher Adams Oil & Gas Specialist British Columbia Ministry of Energy, Mines and Natural Gas Oil and Gas Division Geoscience and Strategic Initiatives Branch Victoria, British Columbia Phone: (250) 953-3763

BRITISH COLUMBIA	
Initiative Title	**British Columbia Oil & Gas Exploration Activity Report 2006**
Initiative goal	To assess the state of exploration and development in northeast British Columbia (conventional and unconventional) and to highlight where oil and gas industry activity was occurring in the province in 2006.
Initiative description Timeline: Released in 2007 for reporting on activity in 2006	Exploration and development activity highlights are covered for six resource regions in northeast British Columbia: Laird Basin and Fold Belt; Fort Nelson/Northern Plains; Fort St. John; Deep Basin; Northern Foothills; and the Southern Foothills. The project also reported on recent activity in the Nechacko Basin and in southeastern British Columbia. The focus was on exploration activity in 2006. Key question included: • Where were the petroleum and natural gas right sold in the province in 2006? • Who are the producers and in what areas are they operating in northeast British Columbia's resource regions? • How successful are these producers in their respective areas of operations? • Where are the new potential areas for growth for natural gas in British Columbia? (e.g. prospects for further development) • What were the latest projects in the Nechako Basin (interior basins)? • Was there activity in southeast British Columbia for coal bed gas development? Land sale activity, industry activity and the latest production numbers are covered for each of northeast British Columbia's oil and gas resource regions, including the Interior Basins and southeastern British Columbia.
Summary of key findings	• Industry activity in the province was robust in 2006 • Drilling activity in British Columbia reached the highest level ever recorded at 1,435 wells. • Raw natural gas production reached over three billion cubic feet (Bcf) per day and conventional oil production was 28,200 barrels per day. • In 2006, the British Columbia Oil and Gas Commission issued 1,730 well licences representing the second highest ever annual level of well licences issued in the province. • Strong demand for natural gas continued to entice producers to boost spending on new exploration projects and develop new supplies. • The trend towards both conventional and unconventional resource play development, promising discoveries, and a fiscal-friendly energy regime continued to give British Columbia a competitive advantage as an oil and gas jurisdiction.

	• Under the Infrastructure Royalty Credit Program, the Province awarded $65 million in royalty credits to 15 companies for 19 road and pipeline projects. • The province initiated the Net Profit Royalty Program to encourage development of technically complex, high-risk projects.
Partners	British Columbia Ministry of Energy, Mines and Natural Gas, Oil and Gas Division, Geoscience and Strategic Initiatives Branch
Key contact	Christopher Adams Oil & Gas Specialist British Columbia Ministry of Energy, Mines and Natural Gas Oil and Gas Division Geoscience and Strategic Initiatives Branch Victoria, British Columbia Phone: (250) 953-3763

BRITISH COLUMBIA	
Initiative Title	**British Columbia Oil & Gas Exploration Activity Report 2007-2008**
Initiative goal	The main objectives of this report are to assess the state of exploration and development in northeast British Columbia (conventional and unconventional) and to highlight where oil and gas industry activity was occurring in the province for 2007-08.
Initiative description Timeline: Released in 2009 for reporting on activity in 2007-08	Exploration and development activity highlights are covered for six resource regions in northeast British Columbia: Laird Basin and Fold Belt; Fort Nelson/Northern Plains; Fort St. John; Deep Basin; Northern Foothills; and the Southern Foothills. The report mainly focused on exploration activity in 2007, but 2008 data was also presented when information for that year was readily available. Key question included: • Where were the petroleum and natural gas right sold in the province in 2007/2008? • Who are the producers and in what areas are they operating in northeast British Columbia's resource regions? • How successful are these producers in their respective areas of operations? • Where are the new potential areas for growth for natural gas in British Columbia? (e.g. prospects for further development) Land sale activity, industry activity and the latest production numbers are covered for each of northeast British Columbia's oil and gas resource regions.
Summary of key findings	• Industry activity in the province was fairly robust in 2008 and was expected to remain strong in 2009. • British Columbia remains the second largest natural gas producer in Canada and the fourth largest for crude oil. • The trend towards both conventional and unconventional resource play development, promising discoveries, and a fiscal-friendly energy regime continues to give British Columbia a competitive advantage as an oil and gas jurisdiction. • Annual marketable natural gas production has increased 40 per cent in the last decade and solid demand for natural gas continues to entice producers to invest in new exploration projects. • Royalty programs, initiated by the British Columbia government, continue to encourage development of technically complex, high-risk projects. • The British Columbia Energy Plan (released in February 2007) outlines specific steps required to develop realistic and achievable goals for conservation, energy efficiency and clean energy.

Partners	British Columbia Ministry of Energy, Mines and Natural Gas, Oil and Gas Division, Geoscience and Strategic Initiatives Branch
Key contact	Christopher Adams Oil & Gas Specialist British Columbia Ministry of Energy, Mines and Natural Gas Oil and Gas Division Geoscience and Strategic Initiatives Branch Victoria, British Columbia Phone: (250) 953-3763

BRITISH COLUMBIA	
Initiative Title	**Summary of Shale Gas Activity in Northeast British Columbia 2007**
Initiative goal	The main objectives of this report are to assess the state of shale gas play exploration and development in northeast British Columbia and to highlight where shale gas industry activity is occurring in the province.
Initiative description Timeline: Released in 2008 for reporting on activity in 2007	This report is an overview of shale gas industry activity covering the key shale gas resource regions in Upper Montney play. These areas include the Horn River Basin, Cordova Embayment, Montney play trend and areas for Cretaceous shale gas targets. The industry statistics presented focus on 2007. Key questions included: • Where were the petroleum and natural gas (PNG) rights sold in the province in 2007? • Which PNG rights were directed towards shale gas development? • Who are the producers and in what areas are they operating in northeast British Columbia's shale gas regions? • How successful are these producers in their respective areas of operations? Land sale activity, industry activity and the latest production numbers are covered for each of northeast British Columbia's shale gas regions: Horn River Basin; Cordova Embayment; and the Upper Montney play and Cretaceous targets. Shale gas play exploration and development activity is covered for 2007.
Summary of key findings	• British Columbia is still in the early stages of shale gas evaluation, but the potential for this new source of gas supply is becoming increasingly significant. • More and more gas discoveries in British Columbia are likely to be made in underdeveloped areas, particularly as producers overcome the technical challenges and complexities of developing unconventional resources such as shale gas • The province has initiated the net profit royalty program to encourage development of these technically complex, high-risk projects.
Partners	British Columbia Ministry of Energy, Mines and Natural Gas, Oil and Gas Division, Geoscience and Strategic Initiatives Branch
Key contact	Christopher Adams Oil & Gas Specialist British Columbia Ministry of Energy, Mines and Natural Gas Oil and Gas Division Geoscience and Strategic Initiatives Branch Victoria, British Columbia Phone: (250) 953-3763

BRITISH COLUMBIA	
Initiative Title	**Summary of Shale Gas Activity in Northeast British Columbia 2011**
Initiative goal	The main objectives of this report are to assess the state of shale gas play exploration and development in northeast British Columbia and to highlight where shale gas industry activity is occurring in the province. Shale gas play exploration and development activity is covered for 2011 and early 2012.
Initiative description Timeline: Released in 2012 for reporting on activity in 2011	This report is an overview of 2011 shale gas activity covering the four key shale gas resource regions in northeastern British Columbia: Horn River Basin; Cordova Embayment; Liard Basin; and the Montney play trend. The report highlights land tenure and drilling activity for each shale gas region. Most of the statistics presented in this report focus on 2011 and early 2012. Key questions included: • Who are the producers and in what areas are they operating in northeast British Columbia's shale gas regions? • How successful are these producers in their respective areas of operations? • Where are the new potential areas for growth for natural gas in British Columbia? (e.g. prospects for further development)
Summary of key findings	• Despite an unfavourable natural gas price regime and lower level of land sale activity in 2011, the shale gas industry in British Columbia continues to provide the province with a distinct competitive advantage as an oil and gas jurisdiction. • Natural gas producers looking to unlock the vast potential of unconventional gas resources in northeast British Columbia are clearly meeting the technical challenges inherent with this type of play development. • Innovative oil and gas royalty programs, such as the Infrastructure Royalty Credit Program, continue to have a noteworthy impact on shale gas activities. This unique Program greatly enhances British Columbia's ability to compete for new areas of oil and gas investment and positions the province well for the opportunity of exporting liquefied natural gas (LNG).
Partners	British Columbia Ministry of Energy, Mines and Natural Gas, Oil and Gas Division, Geoscience and Strategic Initiatives Branch
Key contact	Christopher Adams Oil & Gas Specialist British Columbia Ministry of Energy, Mines and Natural Gas Oil and Gas Division Geoscience and Strategic Initiatives Branch Victoria, British Columbia Phone: (250) 953-3763

ALBERTA	
Project/Study Title	**The Water Conversation with Albertans**
Project/Study Goal	Previous input from stakeholders, including the public, indicated the following priorities for water: • Healthy lakes; • Hydraulic fracturing and water; • Drinking water and wastewater systems; and • Water management. The Water Conversation is designed to test that these are the priorities for Albertans, and, if so, what direction government could consider for moving forward. The hope is that by taking this approach – by testing direction versus going back to a blank page, we are able to leverage the significant amount of work that has been done to-date by Albertans, but also give citizens the opportunity to re-assess and suggest different or revised direction.
Project description Timeline:	Public engagement on water management issues Consultation Phase; February – April 2013.
Summary of key findings	The consultation phase is now over. Ideas shared during the community sessions, through emails and online workbook submissions will be compiled into a "What we heard" report to be released this summer.

QUÉBEC	
Initiative Title	**Étude des mécanismes potentiels assurant l'adoption des meilleures pratiques par les entreprises exploitantes, pour que la responsabilité sociale de l'industrie soit effective (Study on potential mechanisms to promote adoption of best practices by companies operating in the shale gas industry, in order to ensure effective social responsibility by industry)**
Initiative goal	The goal of this study was to identify and analyze the potential mechanisms to promote adoption of best practices by companies operating in the sectors studied, in order to ensure effective social responsibility by industry.
Initiative description Timeline: 2011 - December 2012	The report consists of a study of the mechanisms to promote adoption of best practices by companies operating in the shale gas industry, in order to ensure effective social responsibility by industry. These mechanisms include certification, disclosure and eco-conditionality measures. In order to meet the objectives of their study, the authors considered in their analysis both a range of voluntary mechanisms advocated by various stakeholders and regulatory mechanisms in various jurisdictions (countries, provinces, states) where the shale gas industry is under development. Their study dealt with two complementary aspects: • high-level analysis of the consideration of corporate social responsibility (CSR) issues in the authorization process in various regions in North America and Europe; • analysis of a range of mechanisms aimed at promoting the implementation of CSR practices by companies, advocated by various stakeholders: industry associations in various sectors (oil and gas, mining, chemical), governments, standardization organizations, international organizations and other multi-party mechanisms.
Summary of key findings	The application of voluntary mechanisms is a necessary, but not sufficient condition to ensure that the companies operating in the shale gas industry adopt corporate social responsibility (CSR) practices. In order to ensure effective social responsibility by industry, the practices of companies operating in the shale gas industry must be based on a combination of relevant mechanisms, both regulatory and voluntary, governing their activities. The study concludes that the development of the shale gas industry must be governed by regulatory mechanisms in order to ensure compliance with the sustainable development principles outlined in Québec's *Sustainable Development Act*, including the precautionary principle, the principle of

	subsidiarity, the principle of stakeholder participation and commitment, the principle of access to knowledge and the polluter pays principle. The study further concludes that the relevant voluntary mechanisms aimed at ensuring the adoption of CSR practices by companies must take into account the specific environmental and social issues of the shale gas industry, in connection with stakeholder expectations and social responsibility practices (CSR practices) observed in related sectors (mining, oil and gas, chemical).
Participants	Groupe de recherche interdisciplinaire en développement durable (GRIDD), HEC Montréal

YUKON	
Initiative Title	**Public Dialogue**
Initiative goal	A public dialogue around proposed shale oil and gas activities in Yukon
Initiative description Timeline: Initiated in November 2012, ongoing	As per a Yukon government motion passed in Yukon's legislature on November 27, 2012, the public dialogue will include three components: • Respond positively to the joint request by the Yukon Conservation Society and Northern Cross Yukon for the government to work with the Yukon Environmental and Socio-economic Assessment Board to improve clarity around assessment of oil and gas projects; • Conduct a full and rigorous scientific review of any proposed oil and gas project at each of the following stages of oil and gas development: exploration, production and reclamation; and, • Work with the Vuntut Gwitchin First Nation and stakeholders to facilitate an informed public dialogue about the oil and gas industry, including risks and benefits of hydraulic fracturing, before any regulatory approvals or permitting allows the use of this activity in the Yukon.
Partners	Yukon Government
Key contact	Perry Diamond A/Manager, Oil and Gas Business Development Yukon Government Phone: (867) 393-7044