INTEGRATED, COLLABORATIVE WATER RESEARCH IN WESTERN CANADA

Presentation to US EPA Technical Workshop, Water Acquisition Modeling: Assessing Impacts Through Modeling and Other Means

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Ben Kerr

INTEGRATED WATER RESOURCES

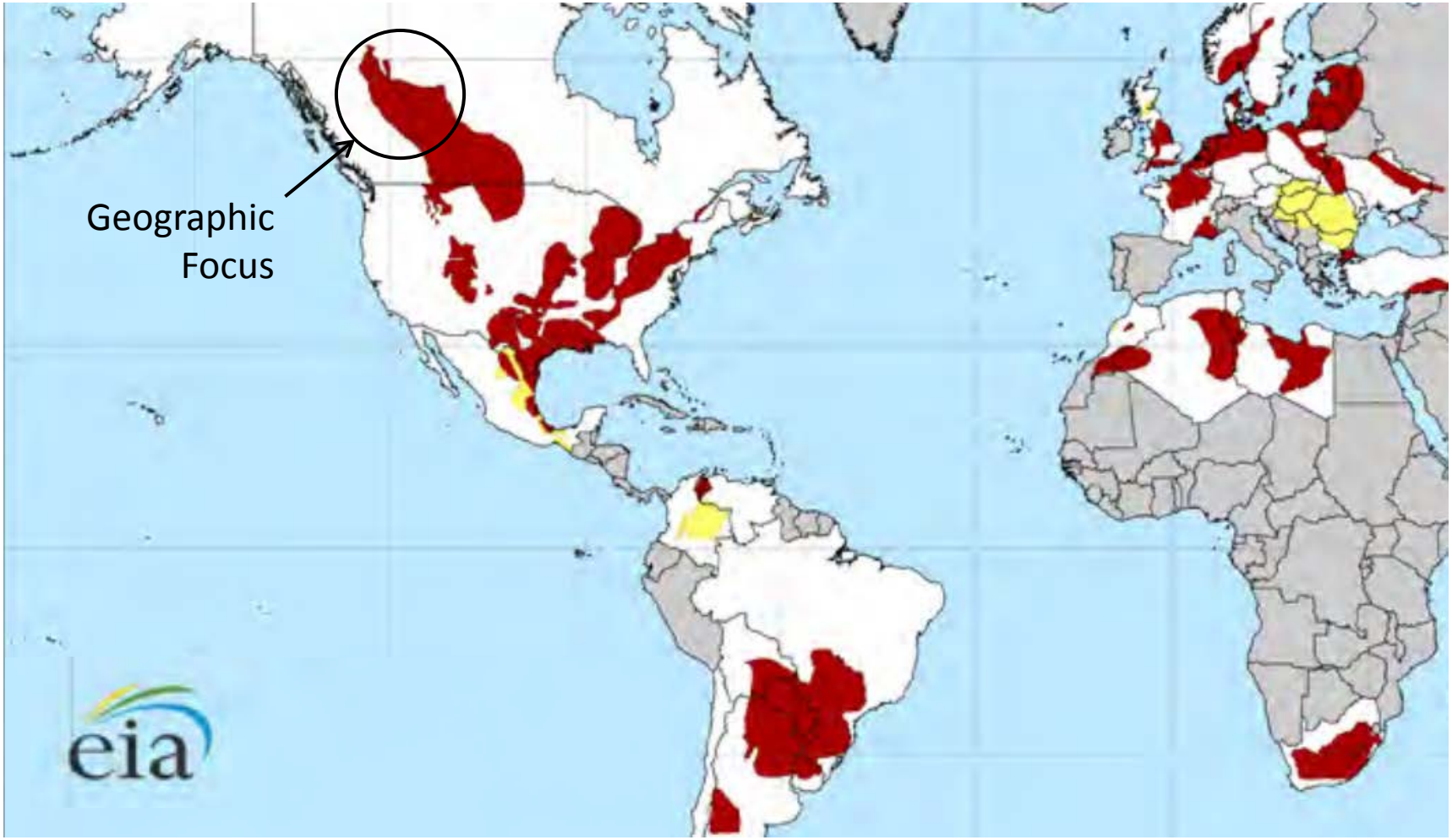
FOUNDRY SPATIAL

Outline

1. Major Western Canadian shale plays
2. Surface characteristics and water requirements
3. Previous water related research projects
4. Northeast British Columbia hydrology modeling
5. Decision support tools for water resource management
6. Integrated Water Resources approach
7. Integrated Assessment of Water Resources for Unconventional Oil and Gas Plays in West-Central Alberta Project
8. Key findings

Introduction

This presentation will provide a summary of the major shale hydrocarbon plays in Western Canada, and describe several regional projects addressed at water sourcing and management challenges associated with hydraulic fracturing.



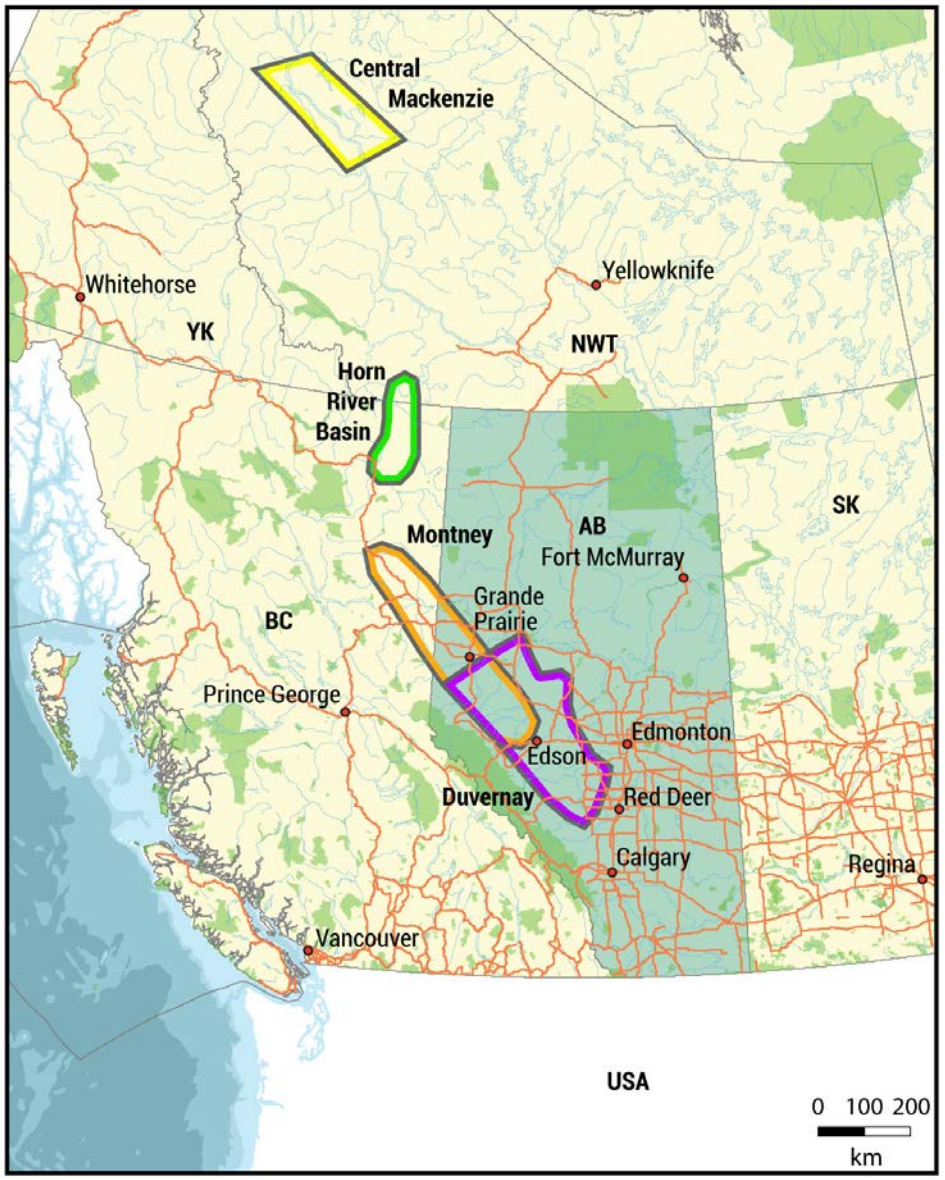
Major Western Canadian Shale Plays

Several major shale plays in Western Canada:

Horn River
Devonian shales over 500m thick, Original Gas in Place (OGIP) volumes over 500 tcf.

Montney
Triassic fine grained silt and sandstones, 300-500m thick, OGIP volumes over 500 tcf (BC), over 2000 tcf, 80 – 220 billion bbl oil (Alberta).

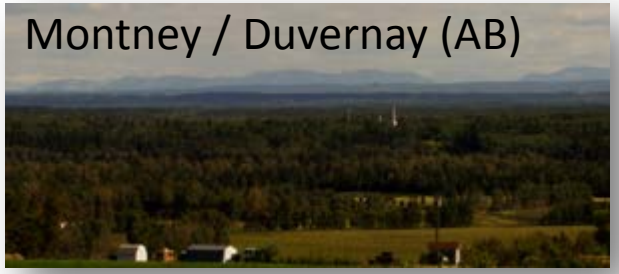
Duvernay
Devonian shales up to 100m thick, OGIP 350-550 tcf, 45 – 80 billion bbl oil.



Surface Characteristics, Water Requirements

- Low relief, muskeg and black spruce, extensive wetlands
- Little pre-existing development or hydrometric and climatic data
- 6 - 18 million gallons water / well

- Foothills / plains transition, coniferous and deciduous forests, range, grassland and non-irrigated crops. Scattered rural development
- Bisected by Peace River, with major tributaries flowing north and south
- 2.5 – 8 million gallons water / well



- Foothills / plains transition, coniferous and deciduous forests, range, grassland, irrigated and non-irrigated crops. Over 100,000 licensed groundwater wells. More developed than BC.
- Several major rivers – Smoky, Athabasca, N. Saskatchewan
- 2.5 - 15 million gallons water / well

Western Canada Water Related Research Projects

2008

- **Horn River Basin Aquifer Project** (Petrel Robertson Consulting)
- Project Sponsors: Geoscience BC & Horn River Basin Producers Group

2010

- **Montney Water Project** (Strategic West Energy, Foundry Spatial, Petrel Robertson Consulting, others)
- Project Sponsors: Geoscience BC, SCEK, ARC Resources, ConocoPhillips, Devon Energy, EnCana, Progress Energy, Shell, Talisman Energy, Province of British Columbia

2011

- **Northeast BC Hydrologic Modeling to Assist with Water Allocation Decisions** (Foundry Spatial)
- Project Sponsors: BC Oil and Gas Commission, BC Ministry of Forests, Lands and Natural Resource Operation, Geoscience BC

2012

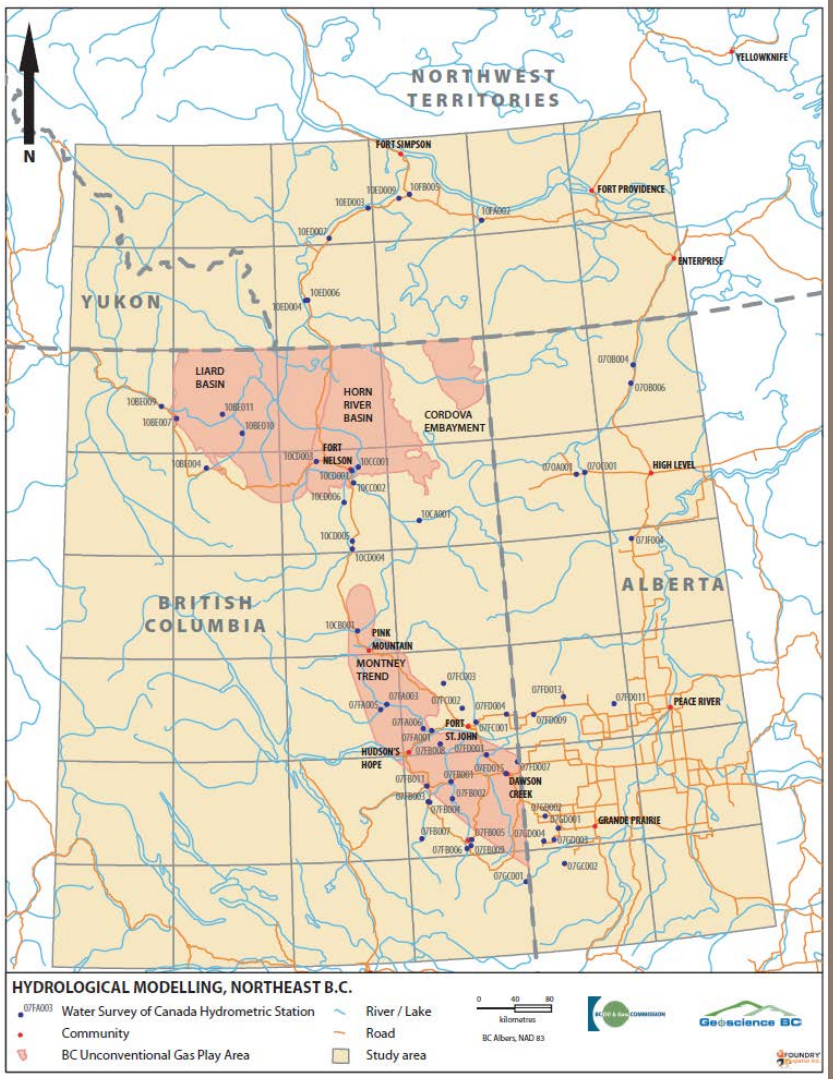
- **Deep Subsurface Saline Aquifer Characterization, Central Mackenzie Valley, NWT** (Petrel Robertson)
- Project Sponsor: Northwest Territory Geoscience Office

2013

- **Integrated Assessment of Water Resources for Unconventional Oil and Gas Plays, West-Central Alberta** (Foundry Spatial, Strategic West Energy, Petrel Robertson
- Project Sponsors: Petroleum Technology Alliance of Canada, Canadian Association of Petroleum Producers, Canadian Natural Resources, Cequence Energy, Chevron, ConocoPhillips, EnCana, Husky, Shell, Talisman Energy

Northeast British Columbia Hydrology Modeling

- Sparse network of hydrometric and climate monitoring stations
- Fully distributed, physically based equation model (conservation of mass)
- High spatial resolution inputs used to model long term annual and monthly runoff patterns.
- Calibrated using vegetation and land use (actual evapotranspiration), cross-validated using existing gauged hydrometric basins.



Co – authors: Allan Chapman, BC Oil and Gas Commission, Dave Wilford, BC Ministry of Forests, Lands and Natural Resource Operations.

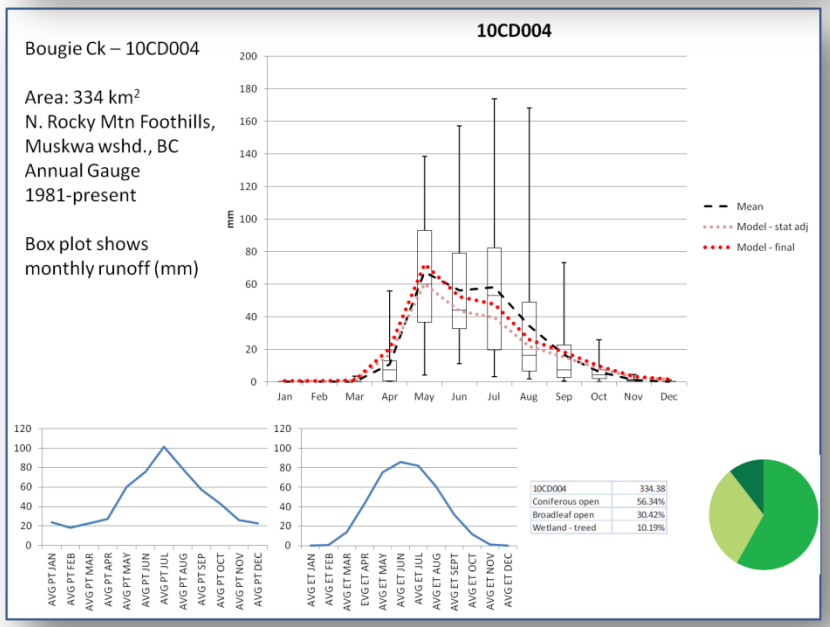
Northeast British Columbia Hydrology Modeling

Model Results:

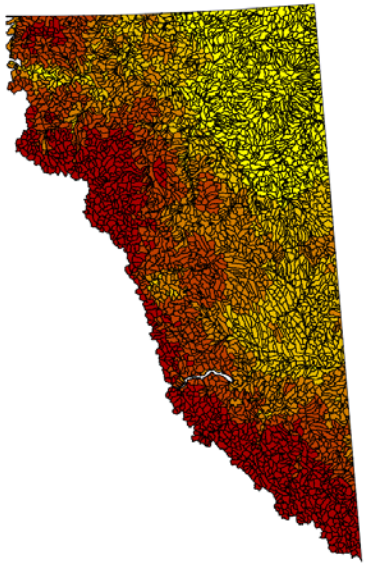
- Annual runoff:

	% of basins within ± 20% error	Mean Error (%)	Median Error (%)	Mean Absolute Error (%)
P-Et model with statistical adjustment	77.8%	5.5%	3.7%	16.1%

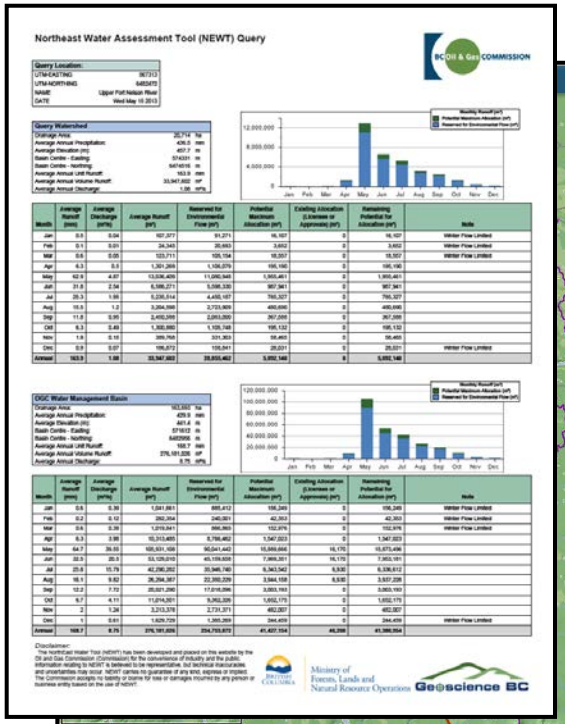
- For seasonal estimates, mean Nash-Sutcliffe score of 0.81, Spearman correlation coefficient 0.97
- Provides good representation of hydrologic regime and runoff volume

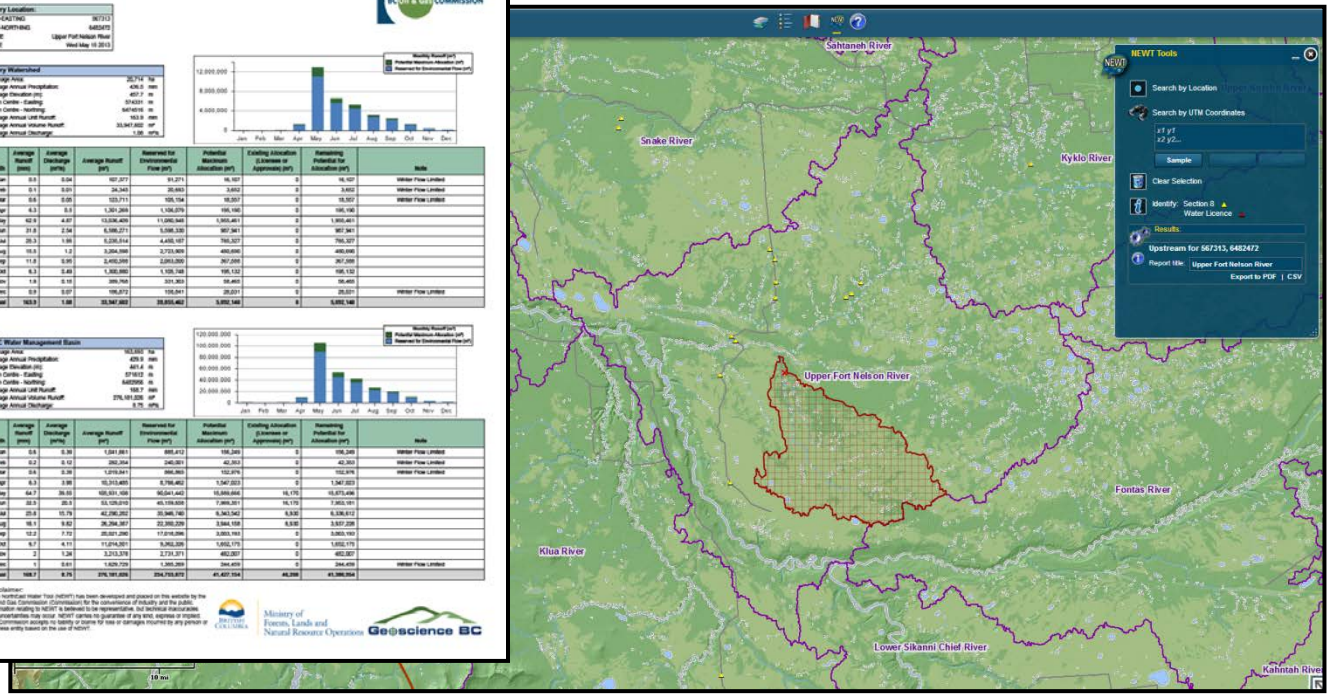


Decision Support Tools for Water Resource Management



1. Apply modeled runoff to fundamental watershed polygons with correct hydrologic topology in a GIS environment
2. Integrate information on existing water allocations and licenses
3. Provide an interactive query tool for decision support via the web





http://www.bcogc.ca/public-zone/northeast-water-tool-newt

Integrated Water Resources Approach

3 Consulting Companies under one umbrella
"Integrated Water Resources"

STRATEGICWEST — **Project Design and Management**

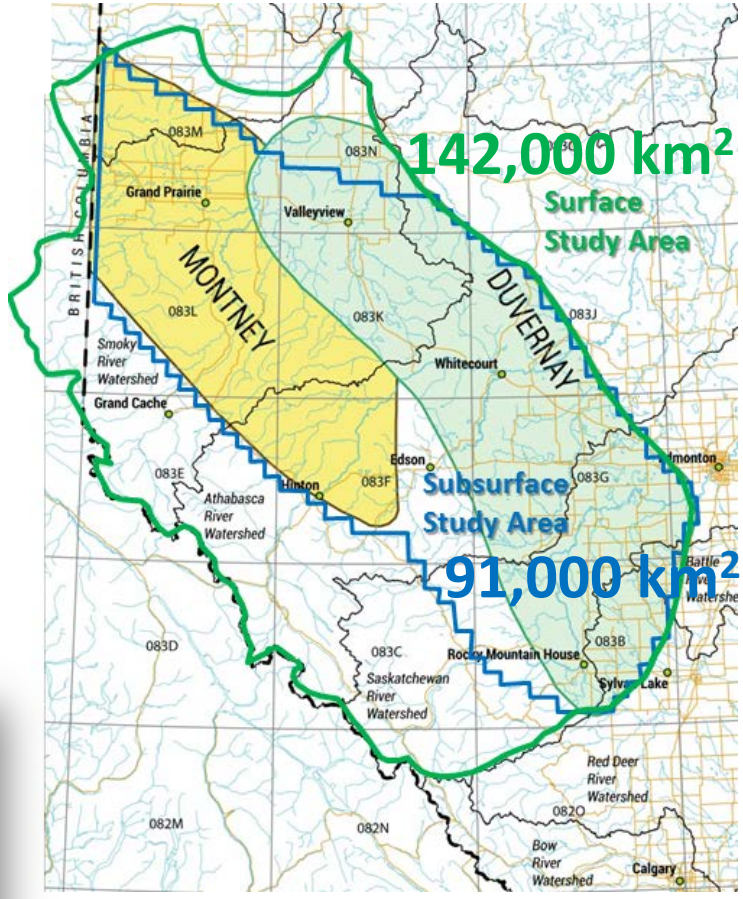
FOUNDRY SPATIAL — **Surface Water & Integration**

Petrel Robertson
Worldwide Petroleum Consulting — **Groundwater – Deep Bedrock & Shallow Aquifers**

- Provide detailed, science-based information on all water sourcing options
- Collaboration – bring together government, oil and gas producers, community groups and other stakeholders
- Integration – present project results in a unified framework, allowing for direct comparison of each option
- Communicate the material to a range interest groups – technical staff (water acquisitions), government licensing bodies, communities and First Nations.

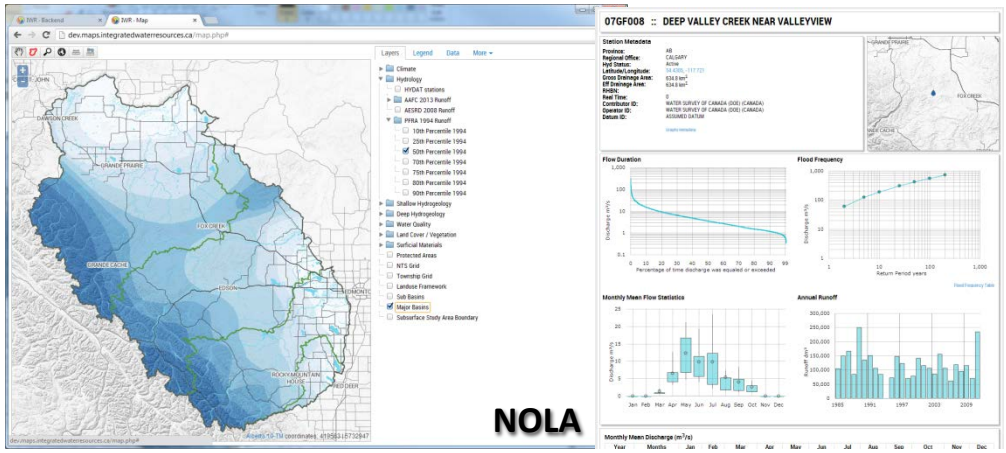
Integrated Assessment of Water Resources for Unconventional Oil and Gas Plays, West-Central Alberta

- Multi-year project , initiated summer 2012.
- Covering Montney and Duvernay play fairways and associated surface watersheds
- Compiling existing data and research results, interpreting key factors controlling water availability, and integrating the results from surface to deep subsurface zones.



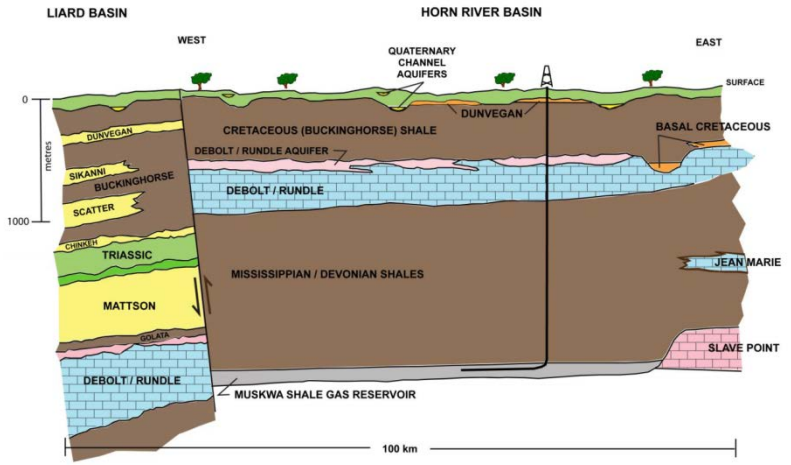
Integrated Assessment of Water Resources for Unconventional Oil and Gas Plays, West-Central Alberta

- Year 2 work includes hydrologic modeling (similar approach to northeast BC)
- Initial project results will become public over the next 6 months
- Integration and communication using NOLA – web mapping framework



Surface Water Resources – Data and interpretation on components of the water cycle – climate, hydrology, vegetation, runoff, soils & geology, etc.

Groundwater Resources – Stratigraphic framework and systematic hydrogeological investigations. Potential productivity assessments for shallow (fresh) and deep (saline) groundwater. Injectivity potential for deep saline aquifers.



Key Findings

Projects completed in Western Canada over the past several years have identified several key factors to success:

- Considering all options for water sourcing in the same context and framework allows for easy comparison and improved communication between regulators, industry and other stakeholders.
- Great value in bringing government, industry, academia and others together to support collaborative geoscience research. Ensures all parties needs are met.
- Multiple participating companies allows for economies of scale and execution of projects at the appropriate play or watershed scale.
- Some jurisdictions are moving toward required collaboration between companies in managing water resources at the play scale – geoscience research on water availability sets the foundation for future collaboration as development levels increase.

Thank You & Acknowledgements

Thank you for the opportunity to present

Acknowledgement of collaborators on past and present projects:

- Strategic West Energy
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- Dendrite Geoscience
- Geoscience BC
- BC Oil and Gas Commission
- BC Ministry of Forests, Lands and Natural Resource Operations
- Alberta Ministry of Environment and Sustainable Resource Development
- Alberta Energy Resources Conservation Board
- ARC Resources
- Canadian Natural Resources
- Cequence Energy
- Chevron
- ConocoPhillips
- Devon Energy
- EnCana
- Husky Energy
- Progress Energy
- Shell
- Talisman Energy

INTEGRATED WATER RESOURCES

For more information:
www.integratedwaterresources.ca