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Amplification of Seismic Ground Motion Hazard Mapping in the Peace River Area

Dawson Creek Open House | May 29, 2019

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Outline

- Project team
- Amplification
  - What is it?
  - How do we estimate it?
- Phase 1 - completed
  - Methodology
  - Comparison of map with recorded ground motions
- Phase 2 - underway
- Acknowledgments

Project Team

Pat Monahan, Monahan Petroleum Consulting

Vic Levson, Quaternary Geosciences Inc. (phase 1)

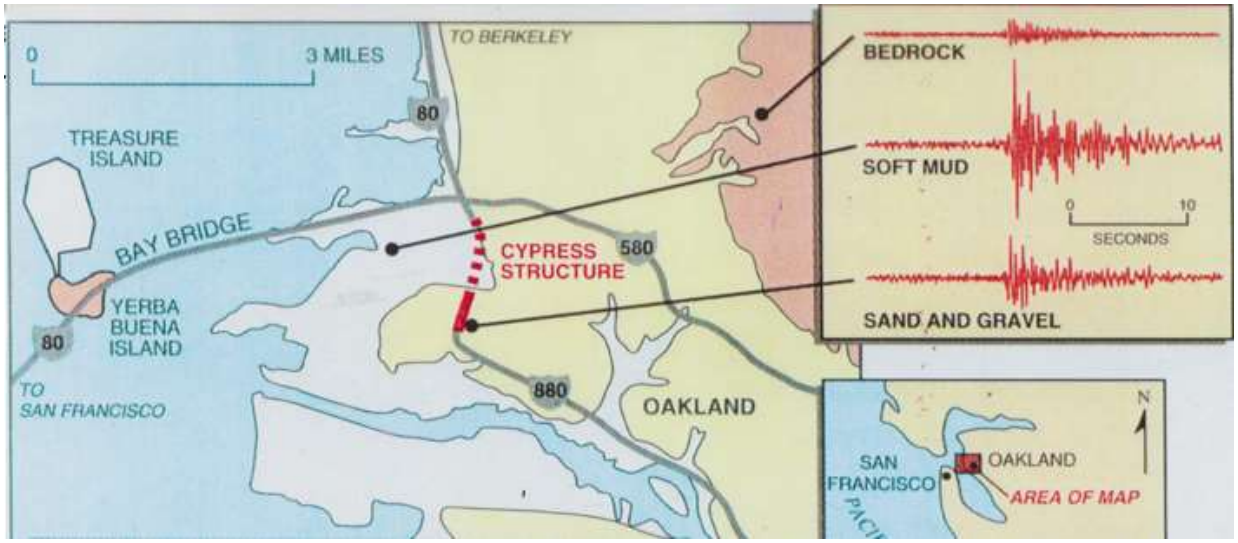
Brad Hayes, Kathleen Dorey, Yevgen Mykula, Ryan Brenner, Jason Clarke, Petrel Robertson Consulting Ltd.

Beth Galambos, Cliff Candy, Cluadia Krumbiegel, Frontier Geosciences Inc.

Mike Robinson and Ufuoma Oki, Northern Geo Testing and Engineering Ltd (phase 2)

Elisabeth Calderwood, University of Victoria (currently Husky Oil Ltd.) (phase 1)

Ground Motion Amplification



Ground Motions amplified on soft soil

- example from 1989 Loma Prieta earthquake

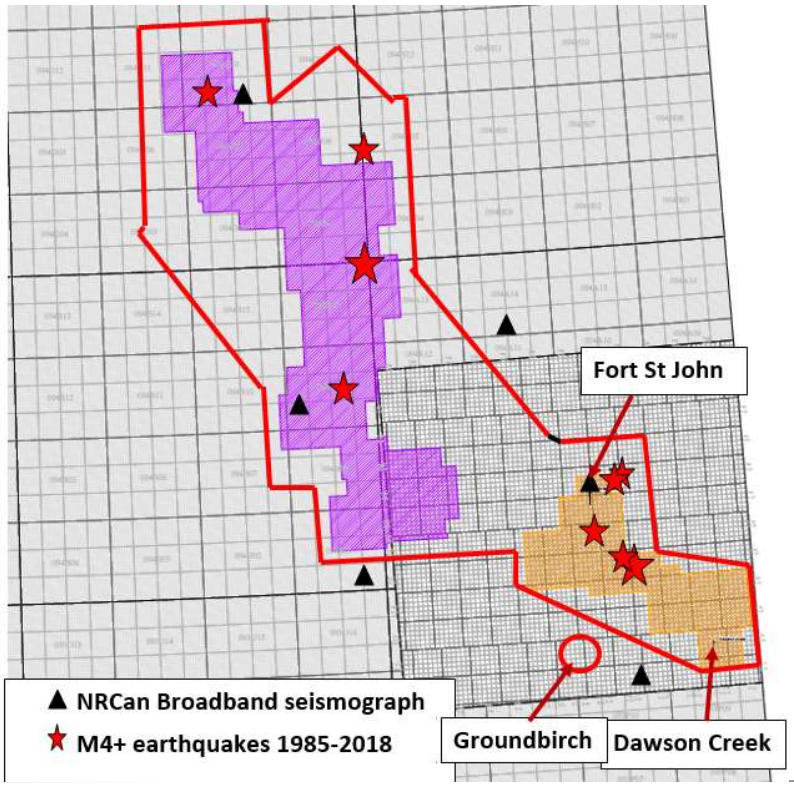
Source: Hough et al., 1990 and Lloyd S. Cluff

Ground Motion Amplification

- Estimated using National Earthquake Hazards Reduction Program Site Classes (NEHRP)
- Used for current building code in USA and Canada
- Based on average velocity of shear waves to a depth of 30m
- As wave slow down approaching the surface, amplitude increases, causing amplification
- Similar to ocean waves increasing in height as they slow down on approaching the shore

Shear-wave generated by striking a horizontal beam with sledge hammer, geophone lowered down borehole (red stand-up pipe to right of truck)

Phase 1 Ground Motion Amplification Mapping



Results released February 2019

Area of investigation defined on basis of:

- Distribution of induced earthquakes
- Areas where seismic monitoring required by BC Oil and Gas Commission

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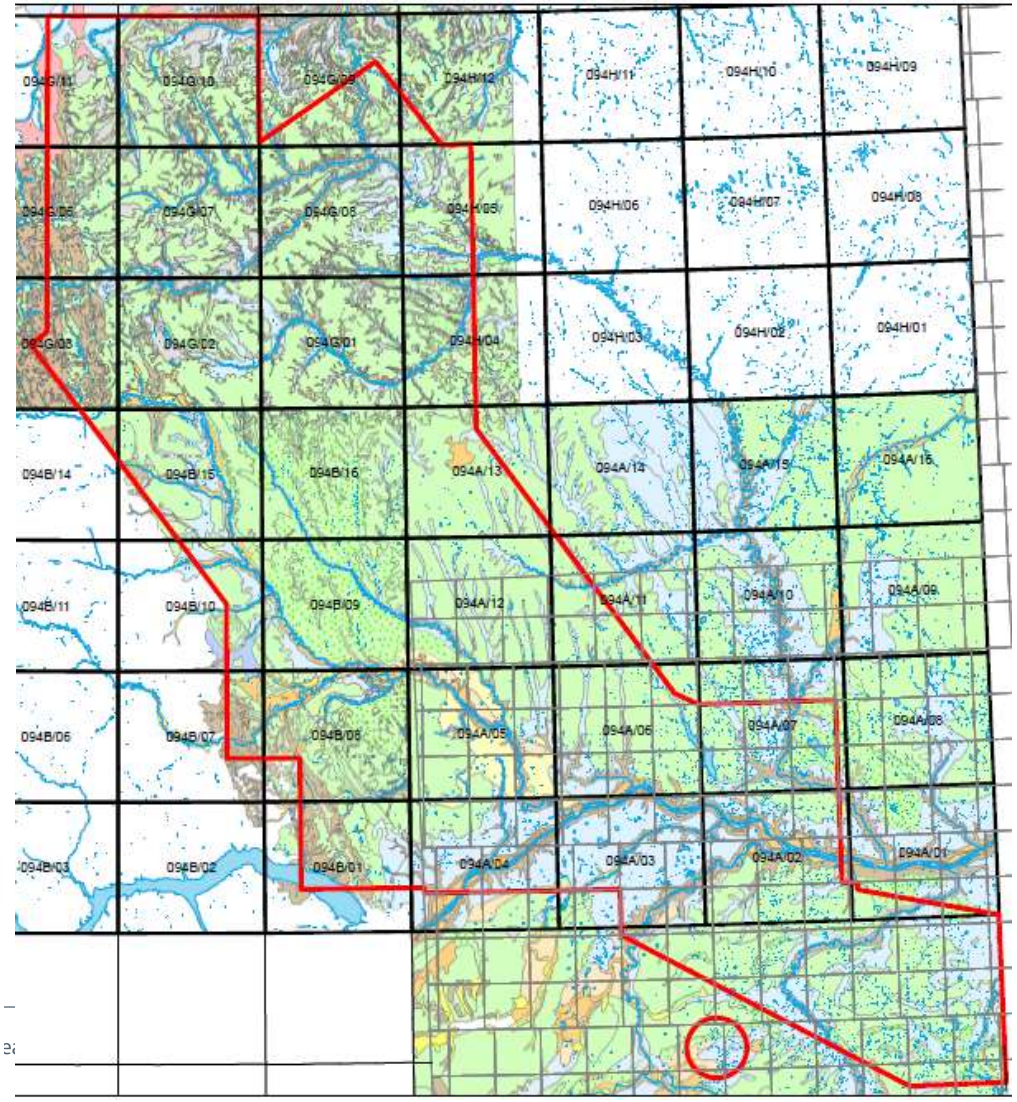
Phase 1 Methodology

Surficial geological map compilation – from existing maps

- 1:250 000 compilation
- Assigned hazard rating based on data from shallow borehole data and new shear-wave velocity data
- Appropriate for regional study with limited subsurface data
- Field work



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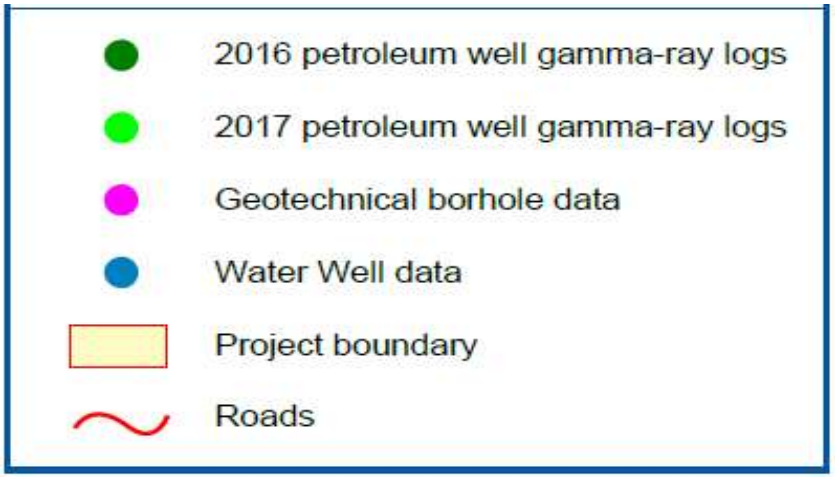
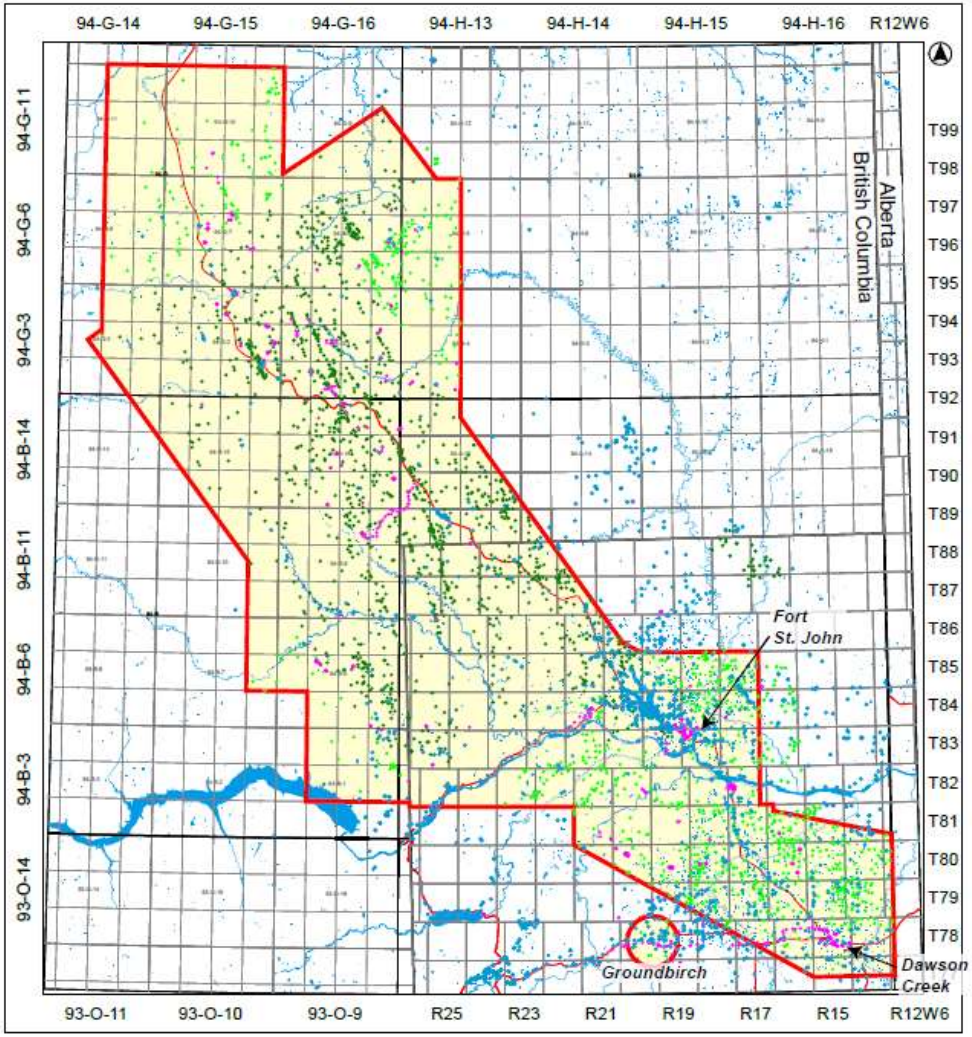
Shallow borehole data

- 2427 oil and gas well gamma ray logs
- 885 Geotechnical borehole logs
- 1831 Water well logs





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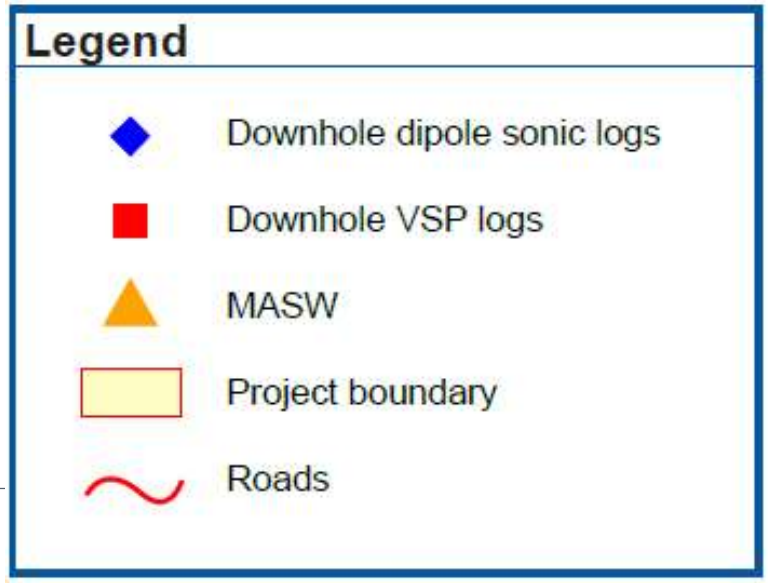
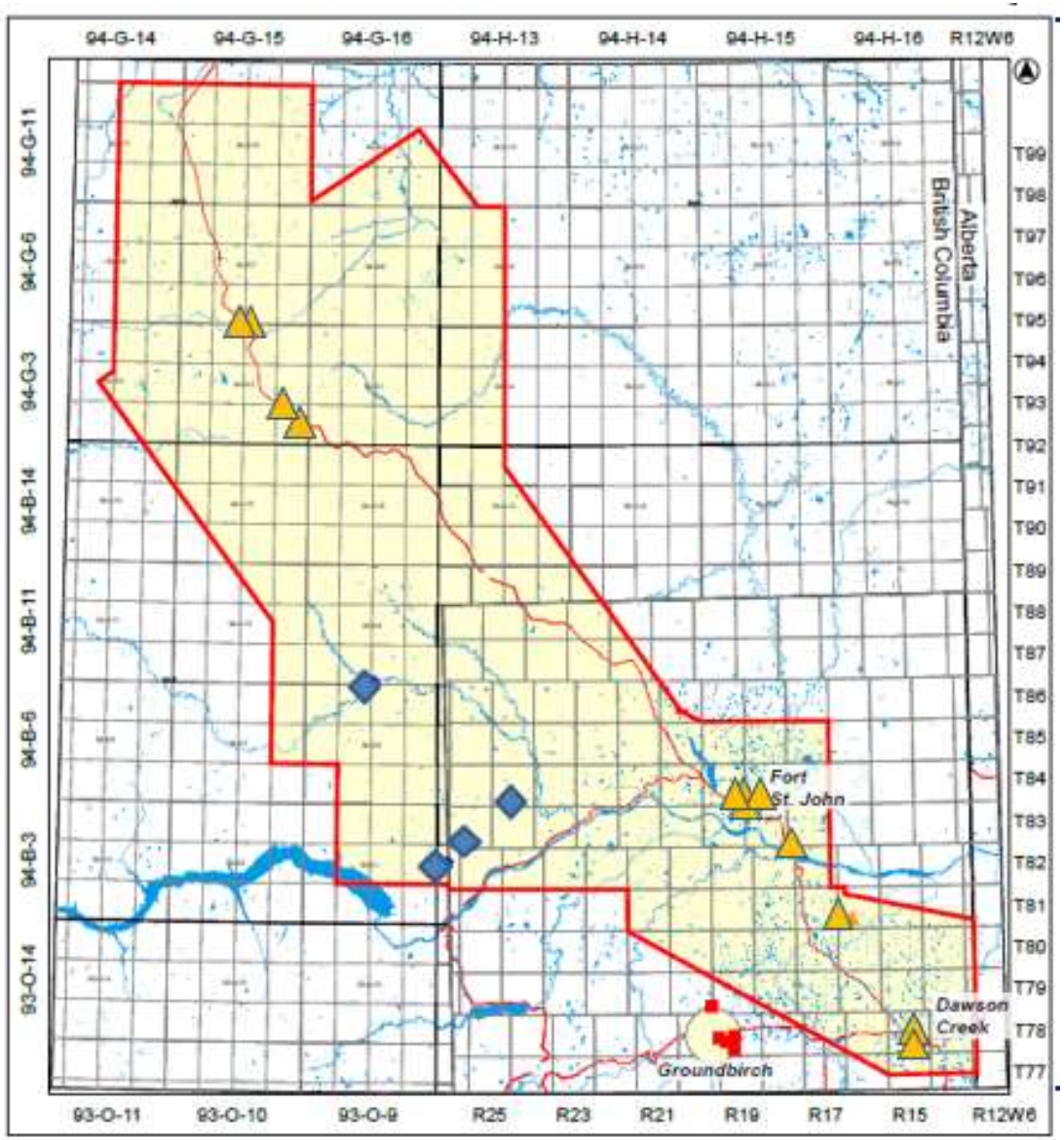
New shear-wave velocity data:

- 10 downhole (existing boreholes)
- 12 MASW (non-invasive)





MASW Sites in Dawson Creek

10th St. Bridge

École Frank Ross geothermal well field

Field Work

Sikanni Chief River Campground

Ostero Gravel Pit, Taylor

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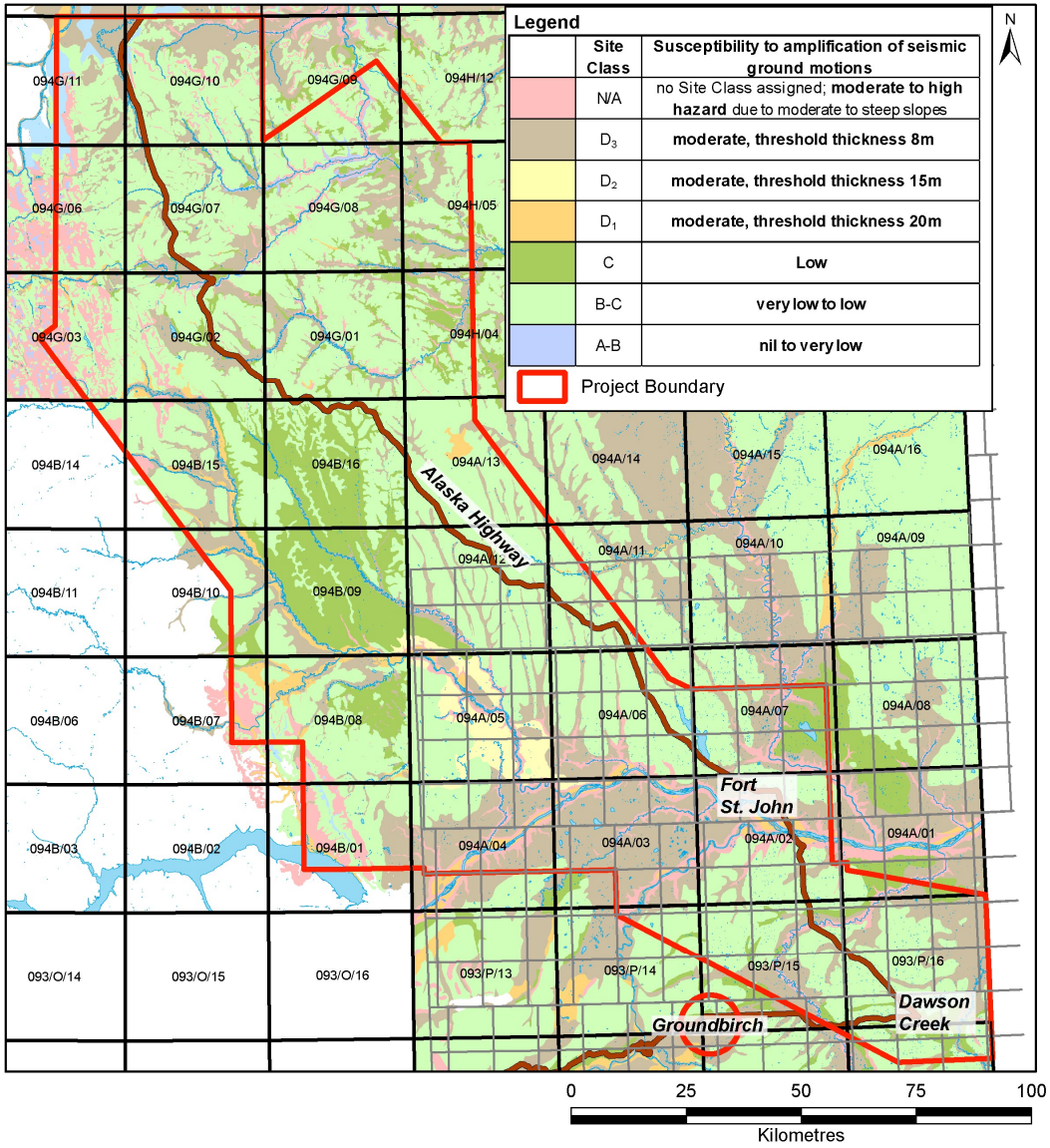
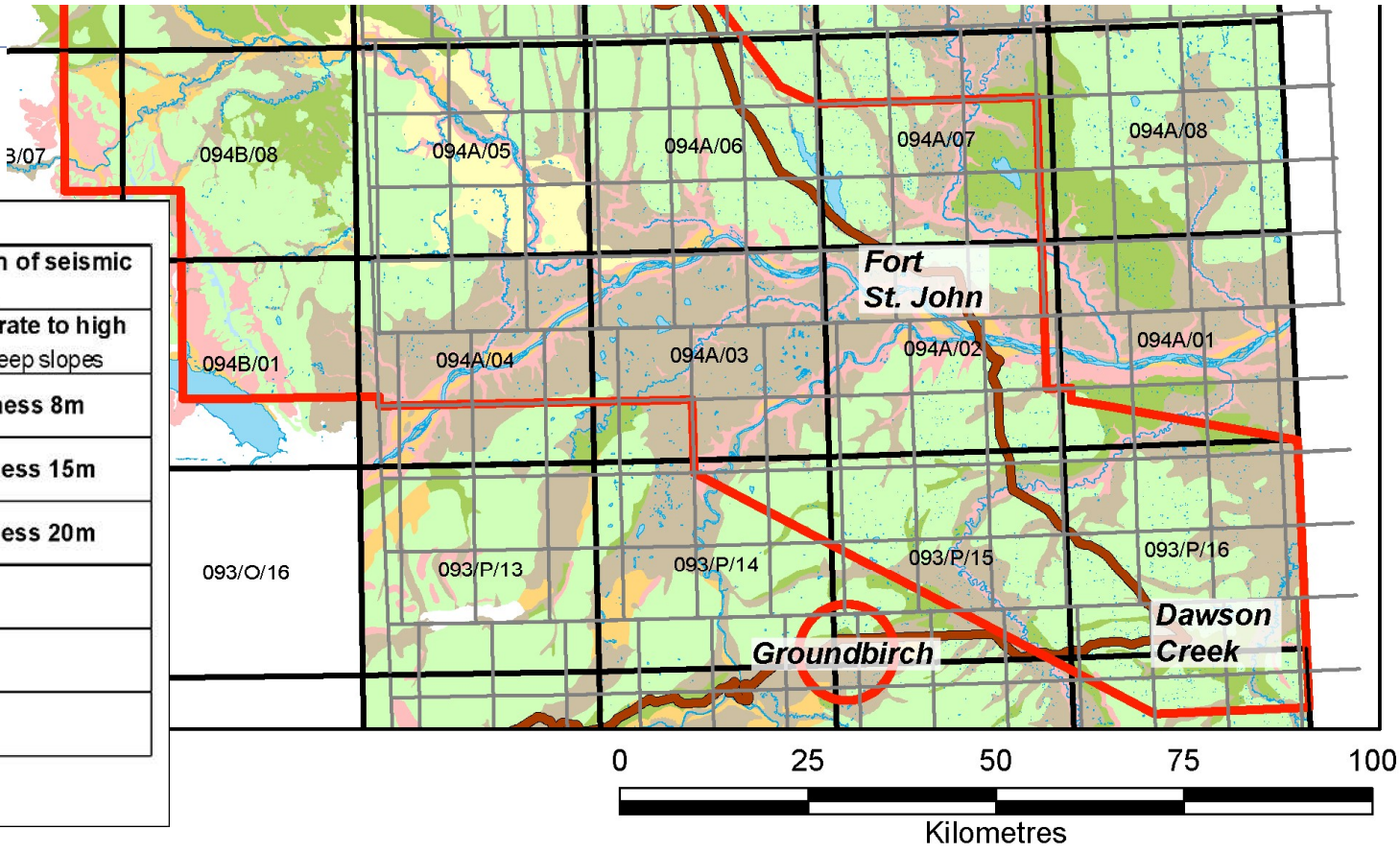
Phase 1 Amplification Hazard Map



Phase 1 Amplification Hazard Map



Legend

	Site Class	Susceptibility to amplification of seismic ground motions
	N/A	no Site Class assigned; **moderate to high hazard** due to moderate to steep slopes
	D_3	**moderate, threshold thickness 8m**
	D_2	**moderate, threshold thickness 15m**
	D_1	**moderate, threshold thickness 20m**
	C	**Low**
	B-C	**very low to low**
	A-B	**nil to very low**

Project Boundary

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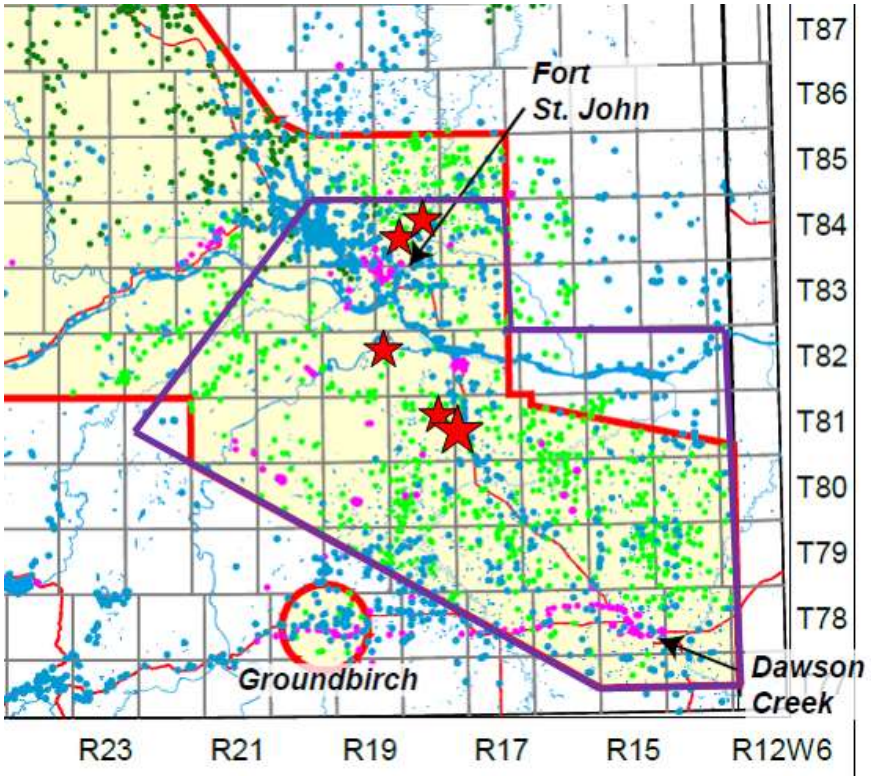
Comparison of Map with Recorded Ground Motions at Seismograph Stations

- **Ground motions at industry stations**
  - Calculated amplifications based on ground motion equations prepared by Ali Mahani and Honn Kao
- **Mapped amplification assignments generally OK**
- **Exceptions occur**
- **Some easily explained**
  - Susceptible sediments too thin to cause amplification
- **Others not so easily explained!**
  - Resonance - at thin soil sites, amplification of specific periods of ground motion can occur
  - 3-D, topography

Phase 2 Ground Motion Amplification Mapping

- **Focus on Fort St. John- Dawson Creek**
- **1:100 000**
- **Better define of surficial geology**
- **New mapping to better reflect the thickness of susceptible sediments**
- **Requires more extensive collection of geotechnical and other borehole data**
  - 460 more oil and gas industry gamma ray logs processed for interpretation
  - Contacting all companies operating in the area, re-contacting all municipal and provincial sources



Phase 2 Ground Motion Amplification Mapping

- Better understand geological factors controlling amplification
- New shear-wave velocity data at sites with high ground motions
  - Seismograph stations and residences
  - MASW
- Requires identifying and visiting sites where earthquake ground motions are felt repeatedly
  - Additional borehole data will provide better assessment of site geology
  - likely amplification sites, and potential sites for MASW
- ***To do this we need your help!***
- ***All information received will be kept confidential***

Acknowledgments

- For assistance in geotechnical borehole data collection:
  - Northern Geo Testing and Engineering; Aurora Engineering & Construction Services Ltd.; Smith + Andersen; Field Engineering & Associates Ltd.; City of Fort St. John; City of Dawson Creek; Peace River Regional District; School Board 59; School Board 60; BC Ministry of Transportation and Infrastructure; BC Geological Survey; BC Hydro; Geoscience BC; Northern Health; Northern Lights College; BC Oil and Gas Commission; Progress Energy Canada; Shell Canada; Painted Pony Energy; Black Swan Energy; Canadian Natural Resources; Saguaro Resources; Crew Energy Inc.; Tourmaline Oil Corporation; and AltaGas Ltd.;
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Thank You

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Comparison with Recorded Ground Motions

Moderate Amplification

Low Amplification

Average hazard assessment OK, but there are exceptions