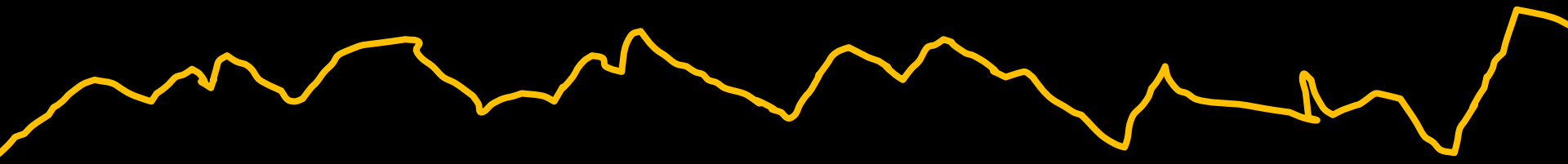
Lessons Learned:

Investigation into Induced Seismicity in the Horn River Basin

Paul Jeakins
BC Oil and Gas Commission

Is Hydraulic Fracturing

Causing Seismic Activity?



Lessons Learned:

Investigation into Induced Seismicity in the Horn River Basin

Commission investigated seismicity in the HRB area and produced a detailed report.

Clear linkage to hydraulic fracturing and seismic activity in the Horn River Area and provided several key recommendations.

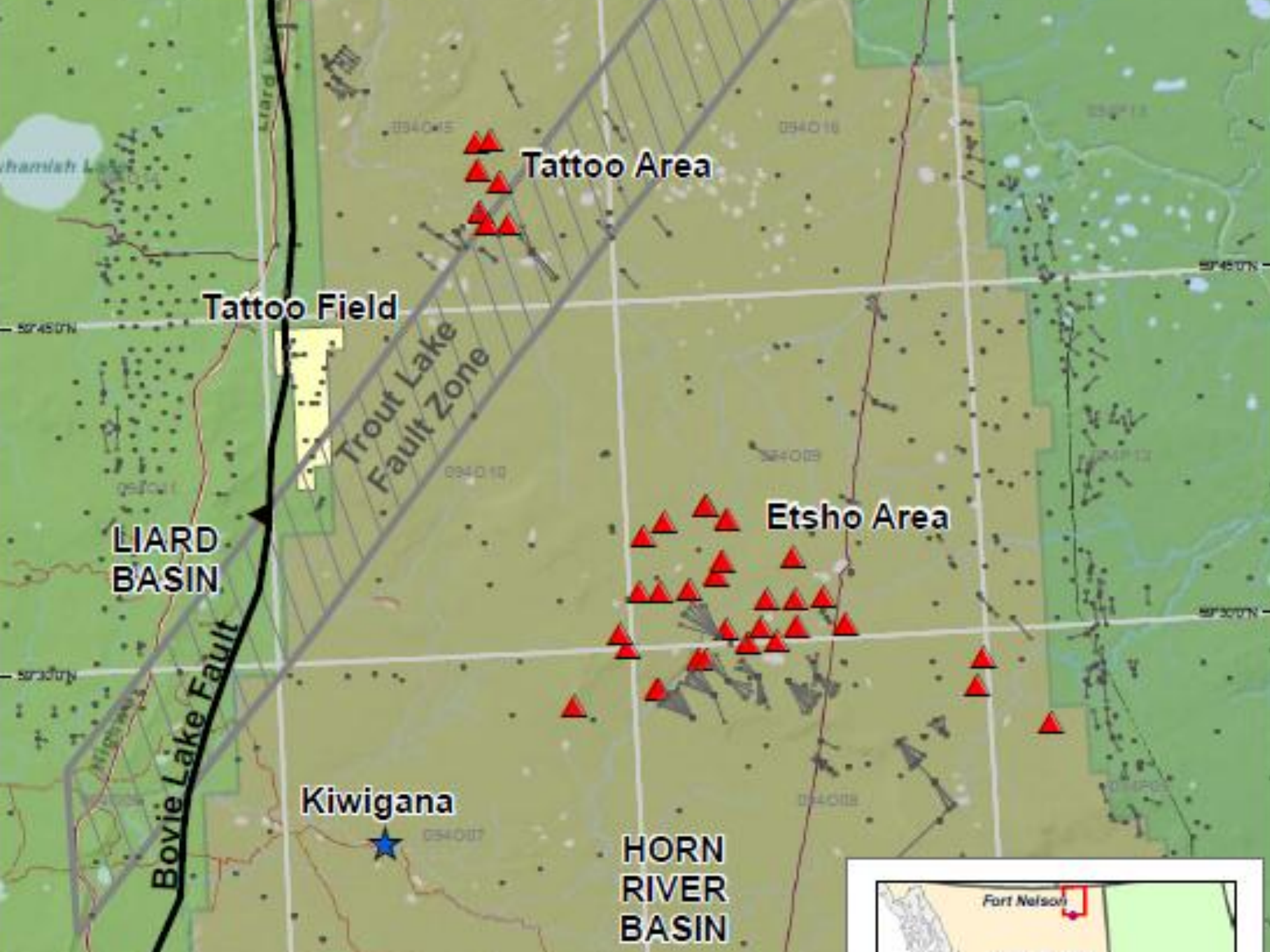
Consultative, concise and well received by industry and media.

Lessons Learned:

Investigation into Induced Seismicity in the Horn River Basin

Lessons Learned on Proactive, Consultative and Transparent Communications

Why investigate
What we were looking for
Who did we involve
What we did publish
How did we communicate


Tattoo Area
Tattoo Field
Trout Lake Fault Zone
LIARD BASIN
Bovie Lake Fault
Etsho Area
Kiwigana
HORN RIVER BASIN
Fort Nelson

Objectives:

1. Examine linkage between oil and gas activities and observed seismicity.
2. Review current research on induced seismicity.
3. Consider mitigation methodologies if a link between oil and gas activities is seen.

Consultation & Transparency

2011 June	NRCan contacts Commission
July	Investigation started
2012 August	Report released
September	Media attention

Investigation Development

Peer review and support from UBC, NRCan, GeoScience BC and Alberta Geological Survey.

Formal Information Request sent to 6 area operators. All fully complied with IR, supplying proprietary data to use in investigation and to support conclusions.

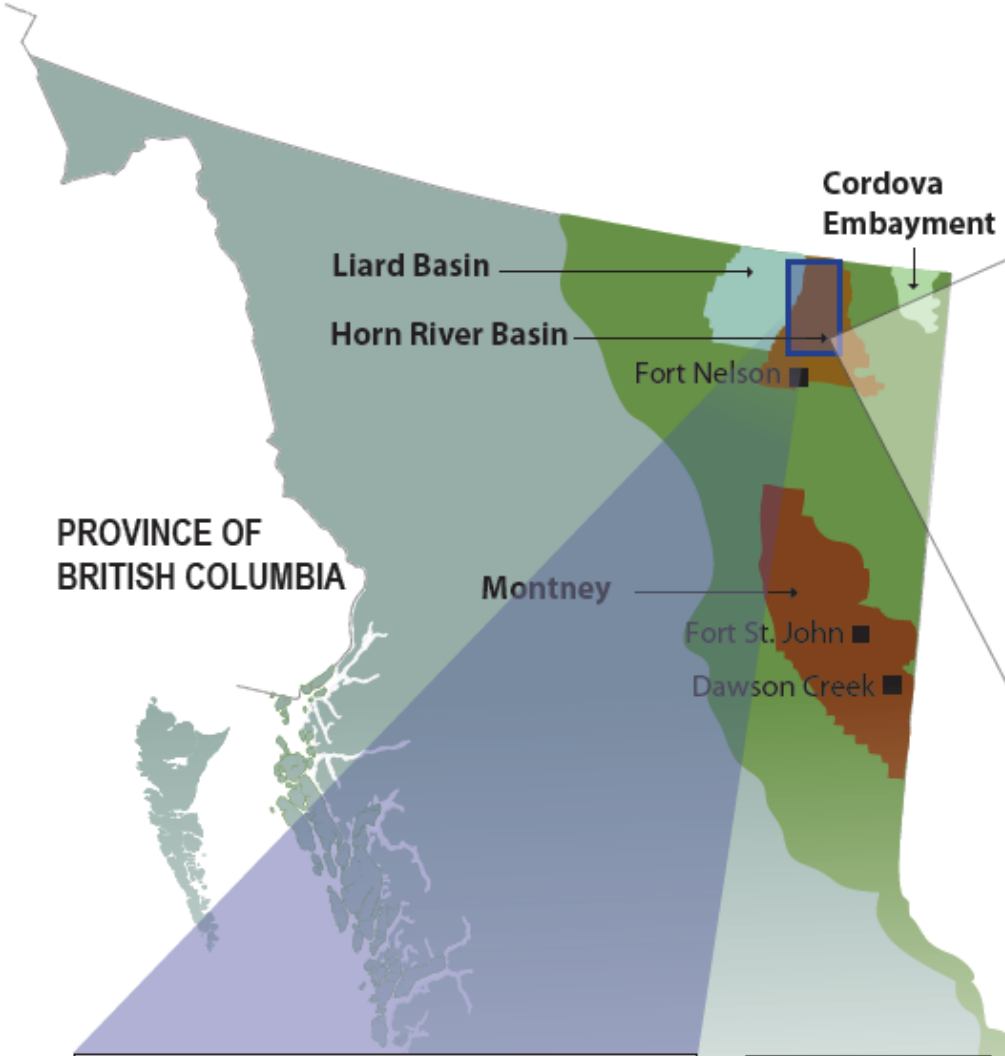
Operators given opportunity to review and comment on report.

Commission Staff
• Expert Analysis of Data
• Scientists/Geologists
• Investigation
• Communications
Industry Operators
• Data
• Peer Review
• Communications
Scientists/Geologists
• GeoScience BC
• NRCan Seismologists
• US experts
• Industry Scientists
Confidential Working Group
Consultative
Fair
Open
Participatory
Challenge Results
Federal & Provincial Government
• NRCan
• Alberta Geological Survey
• BC and Alberta Gov't
• Communications
CAPP
• Peer Review
• Communications
Academia
• UBC
• Literature Search

Investigation Development

FINDINGS

- Seismicity observed was induced by fault movement resulting from injection of fluids during hydraulic fracturing.
- No injuries or property damage were reported. Only one event was felt.
- Fractures developed during hydraulic fracturing were confined to target Horn River shales. No effects to shallow aquifers or the environment were identified.
- The magnitude and frequency of the induced seismicity may be influenced by pump rate, breakdown pressure and proximity to existing faults.
- No casing deformation reported in vertical portion of wellbores. Two instances of minor casing deformation occurred in horizontal well portion of target shale formations. The cause of casing deformation could not be conclusively linked to seismicity.
- Abundant faults are present in the Etsho and Tattoo areas of the Horn River Basin. The faults are generally deep seated and do not extend above the Ft. Simpson shale (a ductile fracture barrier).
- Seismograph station additions are needed to the Canadian National Seismograph Network to improve monitoring.



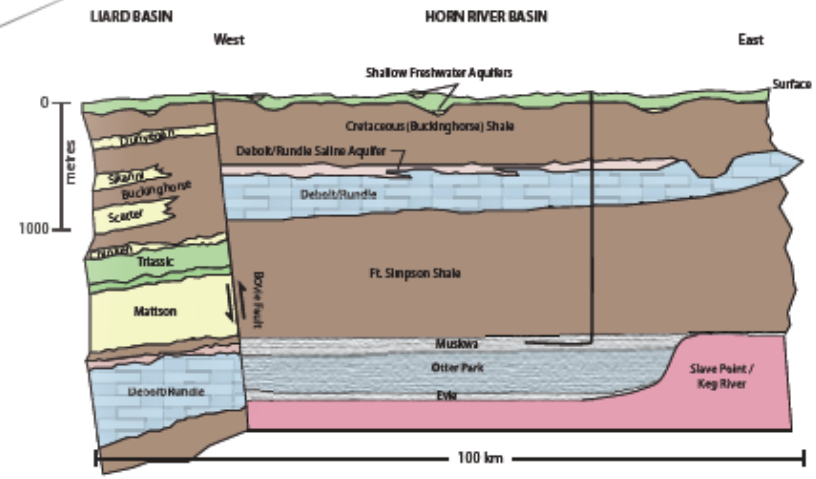


Figure 1. Schematic stratigraphic cross-section, Horn River Basin and adjacent Liard Basin, modified from Petrel Robertson.

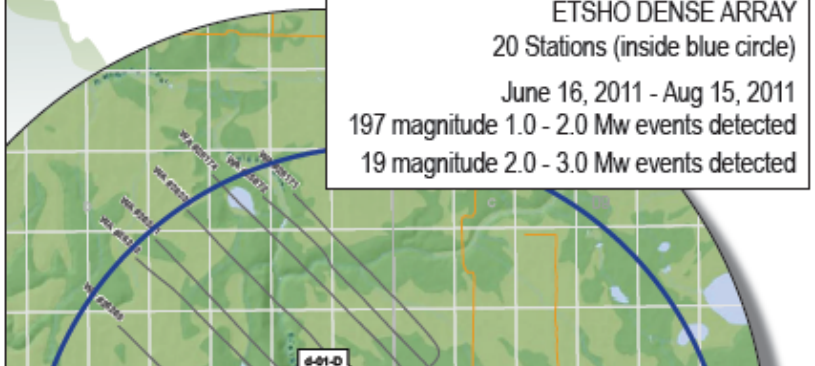
Cross-section of Horn River Basin showing Muskwa, Otter Park and Evie formation shale gas targets. Horizontal wellbores target the Muskwa, Otter Park and Evie zones. Diagram modified from Geoscience BC Horn River Basin Subsurface Aquifer Characterization Project schematic cross-section.

Table of Events collected by the Canadian National Seismograph Nework - Tattoo Area

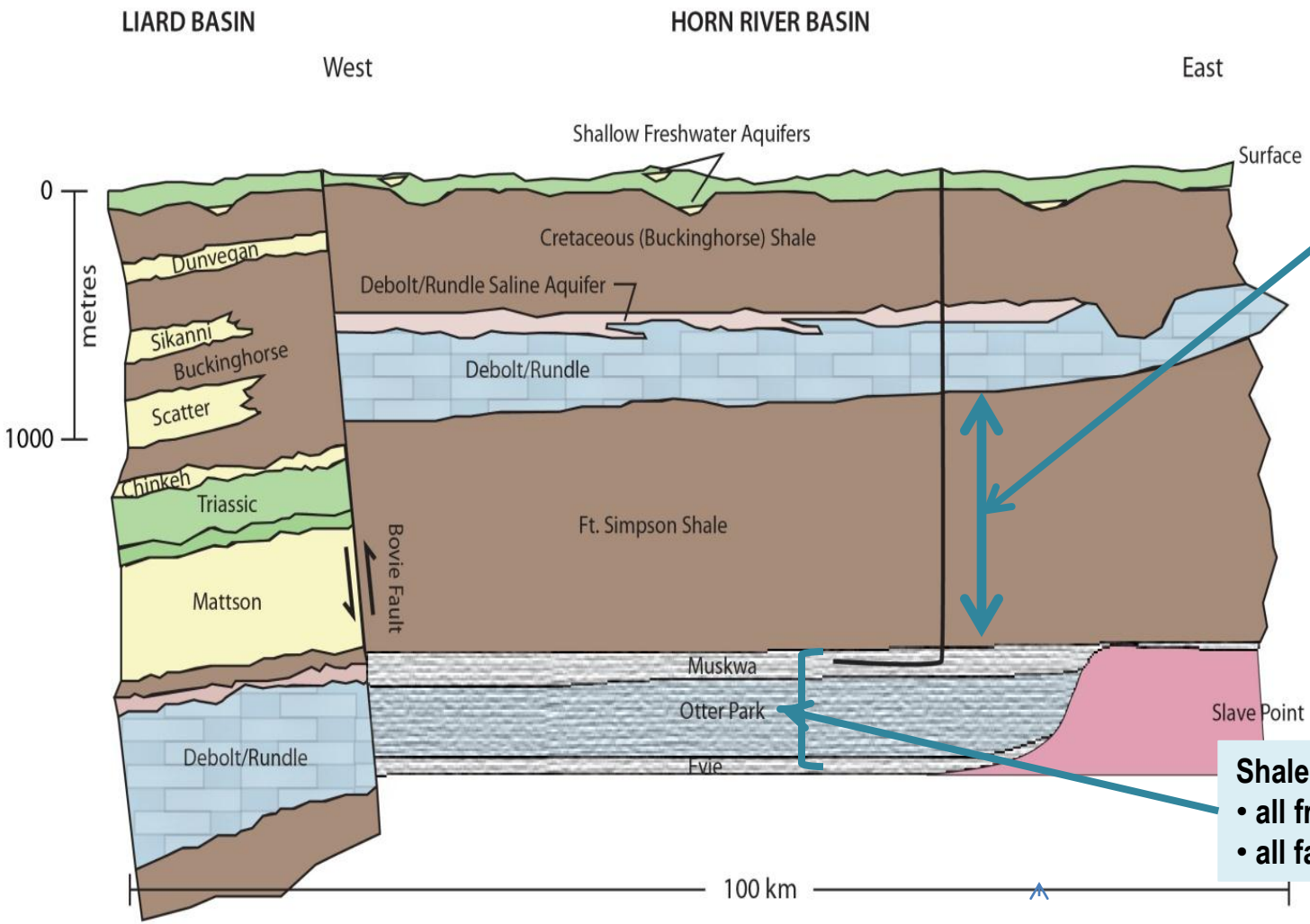
Event #	Date	Mag	Approx location from Fort Nelson	Time (Pacific)
38	2011/12/13	3.1	114 km N	5:17:32
37	2011/12/12	3.1	110 km N	15:34:12
36	2011/12/12	2.9	112 km N	23:59:22
35	2011/12/11	2.4	114 km N	1:15:57
34	2011/12/11	2.9	116 km N	18:37:53
33	2011/12/10	2.9	117 km N	18:52:34

Events were recorded by two types of sources:

1. Canadian National Seismograph Network two stations, Ft. Nelson and Hudson's Hope
2. Operator deployed dense seismograph arrays at Etsho and



Geology of the Horn River Basin



~1,800m separation - shale gas to Debolt disposal zone

Shale Gas Target Intervals
- **all fracking in these zones**
- **all fault movement in this interval**

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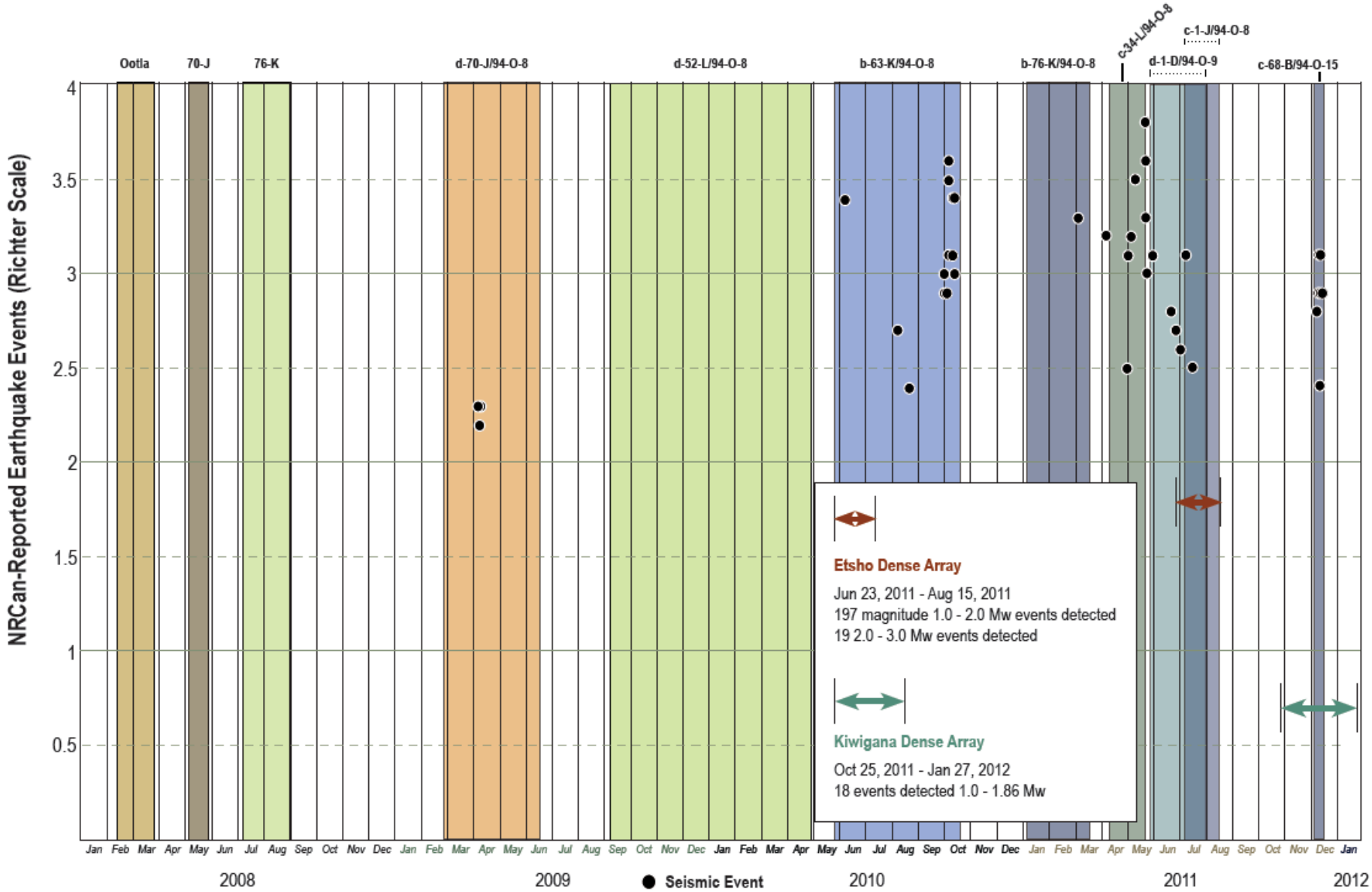


Correlations of Event Times to Horn River Pad Operations

Timing of NRCan reported Events (black dots) vs. Magnitude.

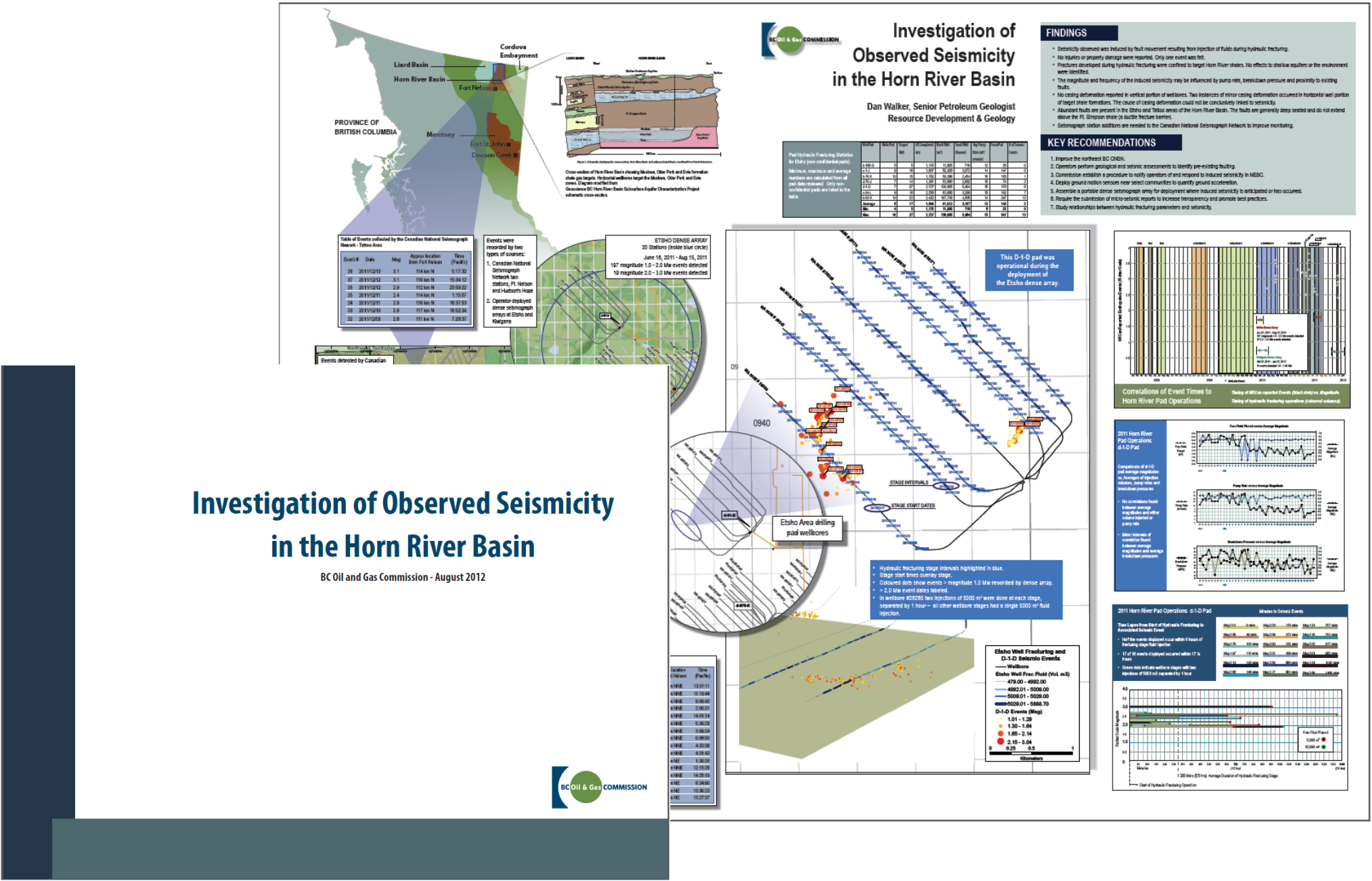
Timing of hydraulic fracturing operations (coloured columns).

Investigation Development

KEY RECOMMENDATIONS

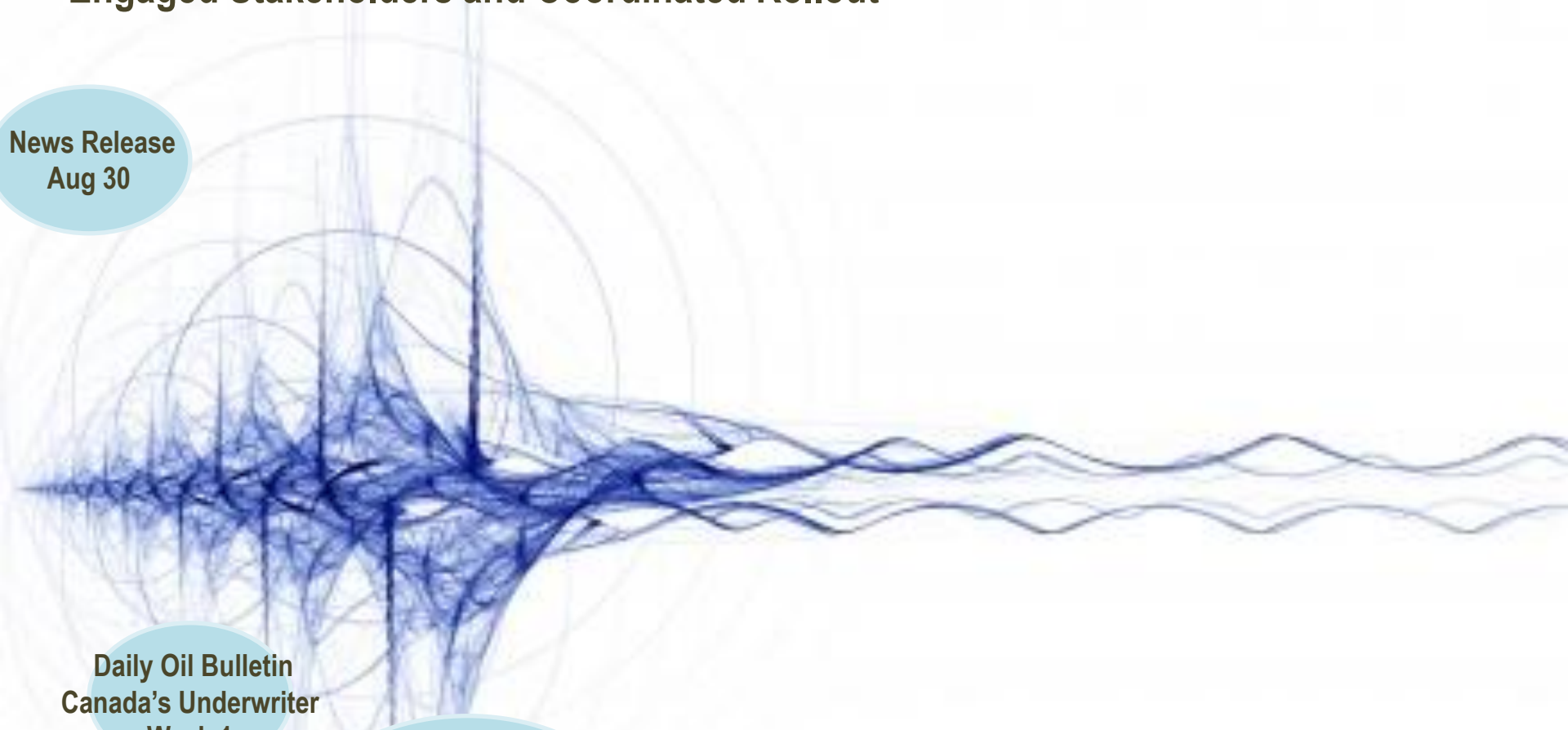
1. Improve the northeast BC CNSN.
2. Operators perform geological and seismic assessments to identify pre-existing faulting.
3. Commission establish a procedure to notify operators of and respond to induced seismicity in NEBC.
4. Deploy ground motion sensors near select communities to quantify ground acceleration.
5. Assemble a portable dense seismograph array for deployment where induced seismicity is anticipated or has occurred.
6. Require the submission of micro-seismic reports to increase transparency and promote best practices.
7. Study relationships between hydraulic fracturing parameters and seismicity.

Investigation Reporting



Communications

Engaged Stakeholders and Coordinated Rollout



News Release
Aug 30

Daily Oil Bulletin
Canada's Underwriter
Week 1

Canadian Newswire Pickup
Major Dailies (print)
Globe and Mail
CBC radio/television
Social media
Week 2-3

Ongoing Activity
Related to seismic
activity in FSJ

Lessons Learned

Proactive
Consultative
Transparent
Communicate

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Seismicity Investigation at www.bcogc.ca