From: Oswell, Terry
Sent: 2019, April 02 11:27 AM
To: Paul Dever (Paul.Dever@crewenergy.com)
Cc: (19), (22)
Subject: Media Request - November Peace Region Earthquake
Attachments: Site C Media draft for review_OGC.pdf

Hi Paul,

The attached document contains BC Hydro's response to a media request. I don't actually know which media. Bob sends his personal regrets for not providing a copy of this to you at the time.

Cheers,
Terry

Terry Oswell | Dam Safety Program Engineer, Dam Safety

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1. ***Was BC Hydro in contact with the Oil and Gas Commission following the incident in late November and if so, what concerns it may have raised at that time?***

   Yes. A teleconference was held on the morning of November 30, 2019—the morning after the earthquake—between representatives of the BC Oil and Gas Commission and BC Hydro, including senior members of the Site C project team and the Dam Safety department. During this meeting, the Oil and Gas Commission provided BC Hydro with its initial findings regarding the earthquake's epicentre, magnitude, and peak acceleration measurements from one nearby instrument. The Oil and Gas Commission further reported that two wells were in operation at the time of the earthquake and that those operations were immediately suspended.

2. ***Did BC Hydro express concerns to the Commission, the company or any provincial government Ministry about the earthquake and its possible impacts on the Site C project or added costs that could be incurred at the project?***

   Other than the teleconferences described in the answer to Question 1, above, BC Hydro has not reached out to express concerns to the Commission, well operators, or any provincial government Ministry about the November 29, 2018 earthquake.

   The Site C project has been designed and is being constructed to resist earthquake ground motions that are well in excess of those experienced as a result of the November 29, 2018 earthquake. Events of this nature are not expected to cause damage to the Site C project.

3. ***Did BC Hydro conduct any site inspections at the Site C site following the earthquake to determine whether any damage may have occurred?***

   Yes. Construction related activities were stopped immediately following the earthquake. BC Hydro and our Contractors conducted safety inspections, commencing at first light on the following morning, to ensure the stability of all construction works and the safety of all site personnel prior to resuming construction. Inspections determined that no damage occurred on site as a result of the earthquake. Instrumentation at site that monitors the performance of excavations and other earthworks did not record any changes that were attributed to the earthquake or interpreted as indicative of damage.

4. ***Does BC Hydro have a clear understanding of what the precise location of the fracking operation or deep well disposal operation was that is suspected of causing the quake, and if so how many kilometres away it is from the Site C dam site?***

   Yes. BC Hydro personnel consulted the information web sites of Natural Resources Canada and the US Geological Survey in the immediate aftermath of the earthquake and in the period following, during which time the epicentre and focal depth estimates were refined. Further, BC Hydro was fully briefed by the Commission regarding the wells that were operating and later determined to be the cause of the earthquake.

   There were two wells—both owned by Canadian Natural Resources Ltd. (CNRL)—in which hydraulic fracture "completion" operations were underway at the time of the earthquake. These were the "G" and "H" wells of CNRL's 5-22-81-18W6 well pad, which is located approximately 20 km from Site C. Both wells were fracturing the Lower Montney formation, and their operations were immediately suspended by the Commission as a result of the earthquake.

   The epicentre of the main M_W 4.5 earthquake has been determined to have been at latitude 56.060°N and longitude 120.677°W with a focal depth of 5.1 km. The subsequent M_L 3.4 and M_L 4.0 aftershocks were centered at 56.057°N and 120.687°W and at 56.029°N and 120.718°W, respectively. These locations are all slightly in excess of 20 km from Site C (latitude 56.198 °N and longitude 120.916°W).

5. ***Does BC Hydro consider the 5-kilometre no-fracking/no liquids disposal zone agreed to between BC Hydro and the Oil and Gas Commission to be all that is needed to ensure that no damage occurs to hydro infrastructure or whether the zone, in Hydro's estimation, should be extended out further still?***

   The 5 km zone applies only to the issuing of new tenures. The BC Oil and Gas Commission has put conditions into place that require existing well tenure holders within 5 km of the Site C dam location to notify BC Hydro of drilling and completion activities. The emphasis is to increase communications between oil and gas operators and BC Hydro and to ensure that oil and gas operations do not conflict with the construction and operation of dam infrastructure. BC Hydro has regular meetings with Crew Energy, who hold well permits within the zone, as described under Question 7, below.

   At this time, BC Hydro is satisfied that suitable diligence is being exercised by permit holders within this zone and sufficient oversight is being provided by the Commission to operate in such a way as not to induce an earthquake that would damage the Site C project.

6. ***Does BC Hydro have its own network of seismographs in place to monitor earthquake activity, and if so how many seismographs it has in place in the Peace region?***

   BC Hydro has strong motion accelerographs at its WAC Bennett and Peace Canyon Dams near Hudson's Hope. There are projects underway to augment these stations with more sensitive accelerographs to allow measurement of small seismic ground motions. These instruments will be tied into the network maintained by Naturals Resource Canada.

   To date, no accelerographs have been deployed at Site C due to the heavy construction that's been underway. A number of accelerographs are planned to be installed as part of the site instrumentation before impoundment (filling) of the reservoir and BC Hydro has been in communication with Natural Resources Canada to coordinate the installation of an accelerograph at Site C in the near future.

7. ***Does BC Hydro regularly receive information from third parties (for example natural gas companies) about what their seismographs detect by way of ground motion?***

   All operators in the region are required to report any measured event of magnitude M1.5 or greater. BC Hydro becomes aware of such events through the Commission. Any measured event in excess of M4.0 in the Peace River region will lead to the immediate suspension of operations, but in the Kiskatinaw Seismic Monitoring and Mitigation Area (KSMMA) in the vicinity of Fort St. John that threshold is lowered to M3.0. BC Hydro is made aware of any such event.

   In January 2017, Crew Energy contacted BC Hydro with a request to meet and gain an understanding of the requirements for notifications and timelines in response to the Commission's directive relating to the 5 km zone described in the answer to Question 5.. Since this initial contact, there have been a number of meetings between Crew Energy and BC Hydro. At these meetings, Crew Energy has updated BC Hydro on their proposed activities in the vicinity of Site C and provided summaries of observed seismicity during their well completion activities. The most recent meeting between Crew Energy and BC Hydro was held on January 14, 2019, and included representatives from the Site C project and BC Hydro's Dam Safety department.

From: Oswell, Terry
Sent: 2019, January 02 8:08 AM
To: Watson, Andrew
Cc: (19), (22) Sebastien Mousseau
Subject: RE: CNRL ground motion data

Done

From: Watson, Andrew
Sent: 2019, January 01 9:10 PM
To: Oswell, Terry
Cc: (19), (22) Sebastien Mousseau
Subject: Re: CNRL ground motion data

Thx terry
Can you forward this to those I have cc'ed. I sent the second email already but this one bounced as internet is not very fast at my location.

Andrew

Sent from my iPhone

On Dec 31, 2018, at 1:30 PM, Oswell, Terry <Terry.Oswell@bchydro.com> wrote:

> **From:** Ali Mahani [mailto:ali.mahani@mahangeo.com]
> **Sent:** 2018, December 22 5:58 PM
> **To:** Oswell, Terry
> **Cc:** Stefik, Ron; Johnson, Jeff
> **Subject:** CNRL ground motion data
>
> Hi Terry,
>
> Attached, please find the raw waveforms that CNRL shared with us for the recent seismic events.
> I will send the McGill waveforms next.
>
> Regards,
>
> Ali
>
> --
> Ali Mahani, Ph.D., P.Geo.
>
> Director, Mahan Geophysical Consulting Inc.
> (mahangeo.com)
>
> Project Seismologist, Induced Seismicity Monitoring Project

BCOGC: 300-398 Harbour Road, Victoria BC V9A 3S1
PGC: 9860 W Saanich Road, Sidney BC V8L 4B2

<CNRL_data.zip>

From: Oswell, Terry
Sent: 2019, February 01 5:06 PM
To: Watson, Andrew; Lord, (19), (22)
Subject: RE: CWR Presentation - 29 Nov event
Attachments: Fracking and Flood Studies.pdf

Here's the presentation – let me know if you'd like to see any addition / deletion. Sorry for the short notice.

From: Oswell, Terry
Sent: 2019, February 01 3:55 PM
To: Watson, Andrew; (19), (22)
Subject: CWR Presentation - 29 Nov event

Hi Andrew, (19), (22)

We've got our annual meeting with the Comptroller's office on Monday and Tuesday next week. I've set aside about 10 minutes on Monday morning to talk about the induced seismic event on 29 Nov and the communications we've had with the OGC since then. I'm going to take content from the OGC website and the responses to the questions that were prepared for the media response earlier this week. I'll send you a copy when I've finished putting the presentation together.

Cheers,
Terry

Terry Oswell | Dam Safety Program Engineer, Dam Safety

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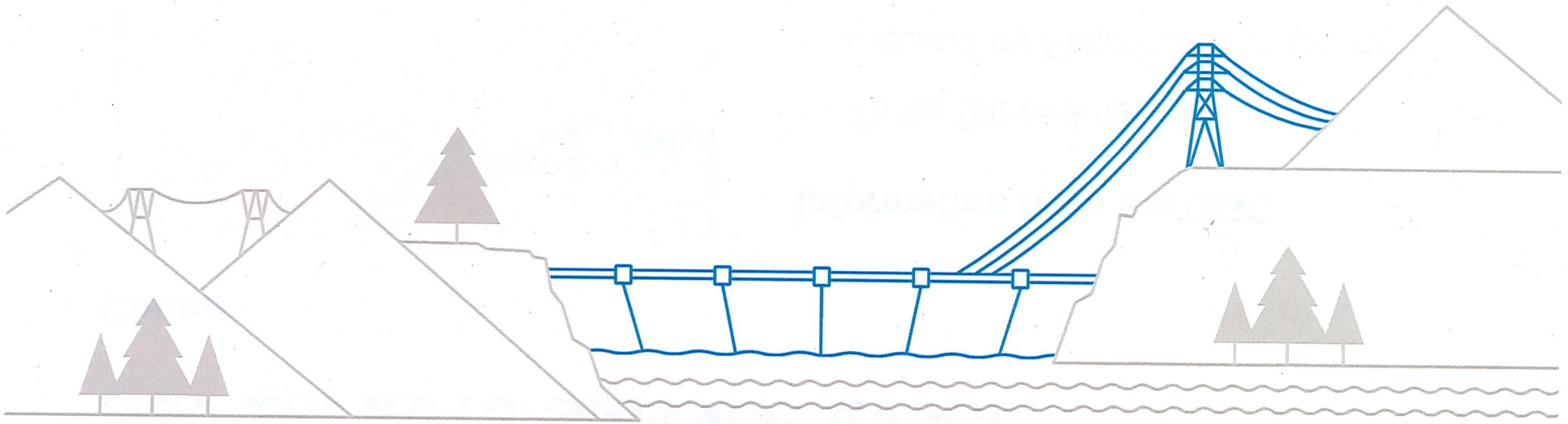
Fracking and Flood Studies



February 4, 2019

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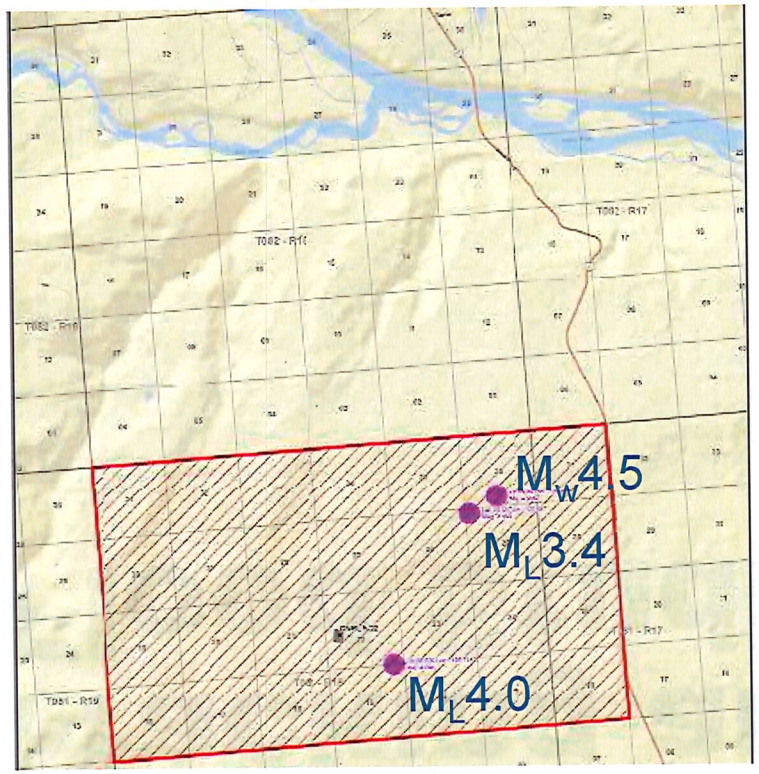
Nov 29, 2018 Seismic Event

Cause



Information from the OGC

- Three felt events
- Caused by Fluid injection during hydraulic fracturing operations by CNRL
- Located in the Kiskatinaw Seismic Monitoring and Mitigation Area
- Immediate shutdown of fracking operations

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Location of epicenters in relation to Site C

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Nov 29, 2018 Seismic Event

Response at Site C

- Felt at site as a “strong jolt”
- Construction related activities stopped immediately following the earthquake
- Workers evacuated from behind cofferdams and tunnels
- Visual inspections carried out next day
- No damage observed
- No changes recorded in instruments

Nov 29, 2018 Seismic Event

Activities since the event

- Communications with the OGC
- Meetings with Crew Energy
- Notification of upcoming activities within the 5 km buffer zone of Site C
- Gathering of data from event

Flood Studies

Status

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