
From: Oswell, Terry
Sent: 2018, December 31 12:30 PM
To: Watson, Andrew; Addo, Kofi; Schubak, Bob
Subject: FW: CNRL ground motion data
Attachments: CNRL_data.zip

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.Geol.

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

From: Oswell, Terry
Sent: 2019, January 14 4:26 PM
To: Addo, Kofi
Cc: Schubak, Bob
Subject: FW: FW: Crew Energy / BC Hydro

Hi Kofi - See Ali's response below. Will you talk to Ali directly to see what can be done, if anything?

From: Johnson, Jeff [mailto:Jeff.Johnson@bcogc.ca]
Sent: 2019, January 14 4:21 PM
To: Oswell, Terry
Subject: FW: FW: Crew Energy / BC Hydro

Hi Terry,

Please see Ali's note below. Probably best if you contact him directly to sort out your data requirements (seed/mini-seed, binary etc). Thanks.

Jeff



Jeff Johnson
Supervisor, Petroleum Geology
Jeff.Johnson@bcogc.ca

Victoria BC
[Office Address Directory](#)
bcogc.ca

T. 250 419-4422
F. 250-419-4403
M. (19), (22)



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From: Ali Mahani <ali.mahani@mahangeo.com>
Sent: Monday, January 14, 2019 3:44 PM
To: Johnson, Jeff <Jeff.Johnson@bcogc.ca>
Cc: Venables, Stuart <Stuart.Venables@BCOGC.ca>
Subject: Re: FW: Crew Energy / BC Hydro

Hi Jeff,

The data shared with BC hydro is in seed format, minised to be precise. That is the exact format that I received from different sources. The only thing is that data is not organized and uniform across all the sources sharing the data. This is especially regarding the instrument response which I have also included in the data shared with them.

I am not exactly sure what they really need to process the data. I was told that they are only comfortable working with full seed data which I don't have. If they could send specific questions that would be better to help them.

Thanks

Ali

On Mon, Jan 14, 2019 at 3:03 PM Johnson, Jeff <Jeff.Johnson@bcogc.ca> wrote:

Hi Ali,

Is there any way to get seed data to BC Hydro for the Nov 29 event rather than binary data? Thanks for your help.

Jeff Johnson
Supervisor, Petroleum Geology
Oil And Gas Commission
2950 Jutland Road
Victoria BC V8T 5K2
T.250 419-4422 | F.250-419-4403 | M. (19), (22)
Jeff.Johnson@bcogc.ca
bcogc.ca

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-----Original Message-----

From: Paul Dever <Paul.Dever@crewenergy.com>
Sent: Monday, January 14, 2019 3:01 PM
To: Johnson, Jeff <Jeff.Johnson@bcogc.ca>
Cc: Terry Oswell <Terry.Oswell@bchydro.com>; Venables, Stuart <Stuart.Venables@BCOGC.ca>
Subject: Crew Energy / BC Hydro

Afternoon Jeff,

Crew and BC Hydro had what I thought was a productive information sharing session earlier today.

I did ask if they received the raw waveform information and they did. However, it was sent as a binary file and would like to have the information as a "seed file".

Would you be able to follow-up with Terry on this? I have included Terry on this request.

Thanks

Paul

Sent from my iPhone

Paul Dever

Vice President, Government and Stakeholder Relations Crew Energy Inc.

Direct: 403-231-3697

Email: Paul.Dever@crewenergy.com

<https://www.crewenergy.com>

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--

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

From: Watson, Andrew
Sent: 2019, January 28 9:49 AM
To: Schubak, Bob
Subject: FW: Induced Seismic Design Requirements

fyi

From: Watson, Andrew
Sent: 2019, January 11 3:40 PM
To: (19), (22) @snclavalin.com
Cc: @bchydro.com
Subject: Induced Seismic Design Requirements

(19),

We recently received some new data from the Oil and Gas commission on the recent earthquake in the Fort St John Area. I understand there may be some analysis underway exploring the sensitivity of the response of some of the structures to a range of potential motions. I understand this work was an expansion of studies previously completed by KCBL/SNC at the request of BChydro, and discussed with the Technical Advisory Board, with a focus on the potential performance of the RCC buttress to induced seismic events. Please take this email as confirmation to discontinue work using the input parameters previously provided. It needs to be determined whether the inputs are suitable to the structures being studied and whether the recent event changes the input.

In terms of update with our discussion with the regulators. The BC Oil and Gas Commission introduced new permit conditions in June 2016 that require the presence of adequate ground motion monitoring during hydraulic fracturing activities. Amendments to the Drilling and Production Regulation introduced in June 2015 require wellbore operations be suspended if they trigger a magnitude 4.0 or greater event, and mitigation measures must be approved by the Commission before operations can continue. In May 2018, the BC Oil and Gas Commission issued a Special Project Order for the Kiskatinaw Seismic Monitoring and Mitigation Area (in the vicinity of Site C) that requires permit holders to suspend hydraulic fracturing operations if an event with magnitude 3.0 is triggered, to mitigate if an event with magnitude 2.0 is triggered, and to report events with magnitude 1.5 or greater.

The BC Oil and Gas Commission has put permit conditions into place that require well permit 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.

We will hold a discussion on the input parameters for any further sensitivity modelling once the ground motions provided by the oil and gas commission have been reviewed.

Thanks
Andrew

Andrew Watson, P.Eng., M.Eng.
Director, Design Engineering
Site C Clean Energy Project
BC Hydro
Suite 1200 745 Thurlow Street
Vancouver, BC V6E 4M3
Tel: 236-455-6715 (direct)

Cell: (19), (22)

Web: www.sitecproject.com

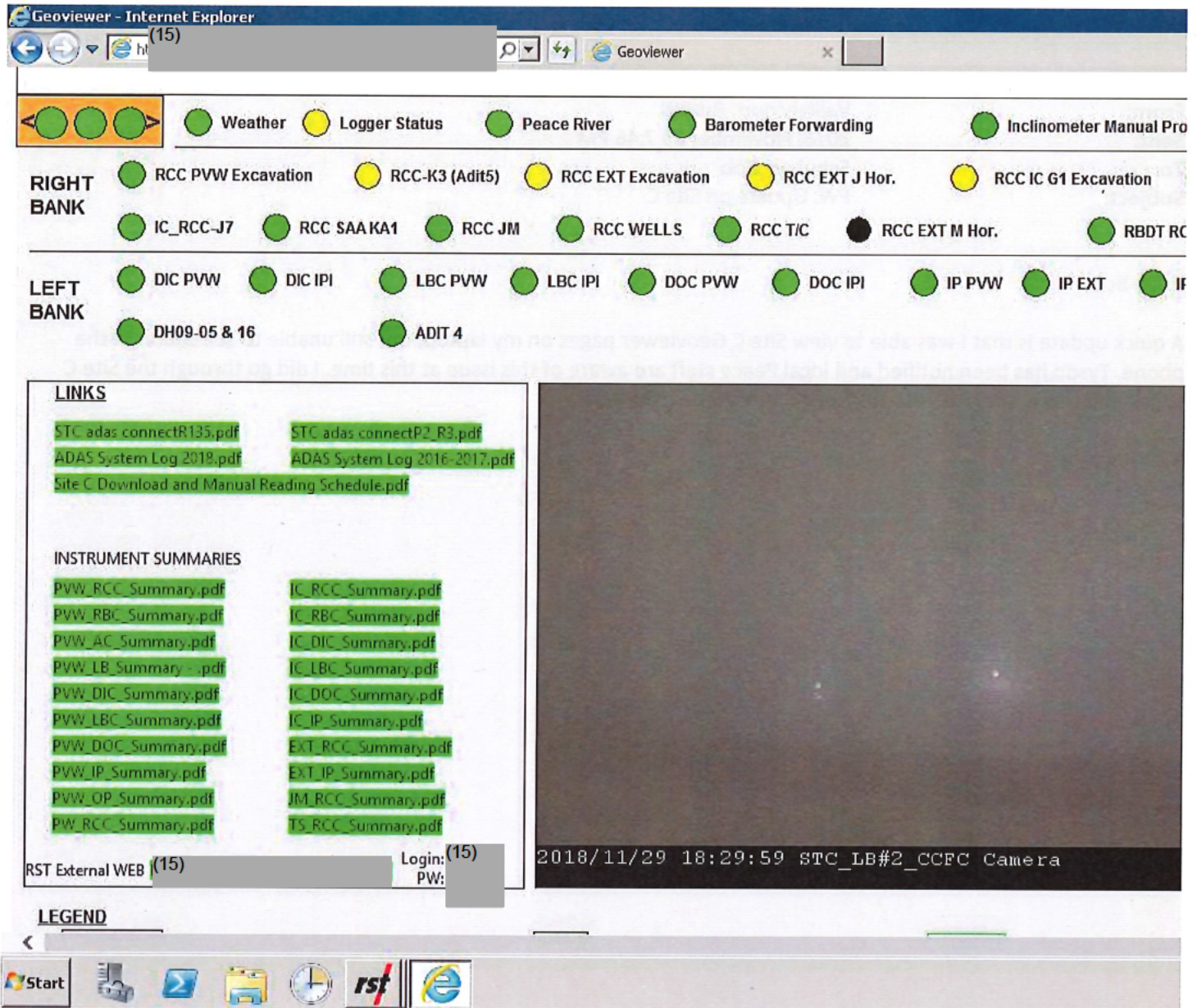
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From: Vaillancourt, Russell
Sent: 2018, November 29 7:46 PM
To: Schubak, Bob
Subject: FW: Update on Site C

Hello Bob,

A quick update is that I was able to view Site C Geoviewer pages on my laptop, but still unable to see them on the phone. Tyson has been notified and local Peace staff are aware of this issue at this time. I did go through the Site C pages and there is no new alarms from the recent earthquake.

Best Regards,
Russell



-----Original Message-----

From: Vaillancourt, Russell

Sent: 2018, November 29 7:19 PM

To: Schubak, Bob

Subject: Update on Site C

Hello Bob,

I am emailing to let you know I will be contacting Tyson as the Site C Geoviewer pages are currently down at the moment. I didn't have any luck connecting up to them at this time. I spoke with James and he mentioned that Tyson should be made aware of this and go from there. There is no impact to GMS server pages.

Can I email you after this gets resolved?

Best regards,
Russell (DSOP)

Sent from my iPhone

From: O'Riley, Christopher
Sent: 2018, November 30 9:38 AM
To: Schubak, Bob
Subject: Fwd: Additional Updated

Sent from my iPhone

Begin forwarded message:

From: "McKenzie, Ken" <ken.mckenzie@bchydro.com>
Date: November 30, 2018 at 7:24:14 AM PST
To: "O'Riley, Christopher" <Chris.Oriley@bchydro.com>
Subject: Additional Updated

It appears there is some different numbers coming out on the size and location of the earthquake. We may not know for sure for awhile. The following is some additional information from Andrew. Once the inspections are completed this morning, I will provide a further update.

Ken

From Andrew:

GSC is reporting it at 4.5. That would be one of the larger in the peace. There had been a series of quakes near the 4.2-4.4 range over past 10 years and some ones in 90's about that large attributed to oil and gas activity. In 2013 we had one about 15 km east (4.3 I recall) and I assumed this might be same formation but latest map shows it further south. It usually takes time to finalize positioning. Latest map from geological survey looks southeast of site c by maybe 10km near pine. Might be close to crew energy operations. We have been working with them (crew) as they are approaching our 5km consultation buffer we put in place with the OGC.

Looks like nearly zero displacement on the cofferdams.

Will touch base with OGC tomorrow. They have increased their (industry) monitoring systems in area.

Ken

Ken McKenzie, P. Eng., MBA
EVP, Site C Clean Energy Project

BC Hydro

T [604 528 2617](tel:6045282617)

M 

F [604 528 2547](tel:6045282547)

E Ken.Mckenzie@bchydro.com

From: Watson, Andrew
Sent: 2018, November 30 3:51 PM
To: Schubak, Bob
Subject: Fwd: Recertification letter for Stage 1 Cofferdams
Attachments: Stage 1 Cofferdam Re-Certification.pdf; ATT00001.htm

FYI

Sent from my iPhone

Begin forwarded message:

From: (19), (22) [redacted] <[redacted]@prhp.ca>
Date: November 30, 2018 at 1:47:05 PM PST
To: [redacted] <[redacted]@bchydro.com>, [redacted] <[redacted]@bchydro.com>, [redacted] <[redacted]@bchydro.com>, Andrew Watson <andrew.watson@bchydro.com>, [redacted] <[redacted]@bchydro.com>, [redacted] <[redacted]@bchydro.com>
Cc: [redacted] <[redacted]@prhp.ca>, [redacted] <[redacted]@prhp.ca>, [redacted] <[redacted]@prhp.ca>, [redacted] <[redacted]@prhp.ca>
Subject: Recertification letter for Stage 1 Cofferdams

Hello BCH,

Please find attached bootleg of sealed recertification letter. Official to follow.

Best,
Mario

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November 30, 2018

Mr. (19), (22)
Project Director
Peace River Hydro Partners
Suite 2600
595 Burrard St
Vancouver, British Columbia
Canada, V7X 1L3

Knight Piésold Ltd.
Suite 1400 - 750 West Pender Street
Vancouver, British Columbia
Canada, V6C 2T8
T +1 604 685 0543
E vancouver@knightpiesold.com
www.knightpiesold.com

Dear (19), (22)

**RE: SITE C CLEAN ENERGY PROJECT – STAGE 1 COFFERDAMS – SEISMIC
EVENT ON 2018/11/29 – RECERTIFICATION OF COFFERDAMS**

As reported by Natural Resources Canada and experienced by most people on Site and in the Town of Fort St. John, on November 29 2018 at approx. 18H27 MST, a 4.5 magnitude earthquake struck approximately 16 kilometres southwest of Fort St. John, B.C.

A seismic event has the potential to cause damage to any structure, in particular and of specific relevance, the Stage 1 Cofferdams as designed by Knight Piésold (KP) for Peace River Hydro Partners (PRHP) for the construction of the Main Civil Works components of the Site C Clean Energy Hydroelectric Project.

The Stage 1 Cofferdams comprise four separate temporary cofferdams; the Diversion Inlet Cofferdam, Diversion Outlet Cofferdam, Left Bank Cofferdam, and Right Bank Cofferdam. The Stage 1 Cofferdams are earthfill embankment dams with a vertical slurry cut-off wall that terminates at (or 1 m into) Sound Bedrock. Further descriptions of the Stage 1 Cofferdams can be found in the Stage 1 Cofferdams Design Report - SCCEP-PRHP-ED-RPT-000001 (PRHP 2017a).

As per the Stage 1 Cofferdams - Operations Maintenance and Surveillance (OMS) Plan - SCCEP-PRHP-QM-PLA-000003 (PRHP 2018a), a Type 2 Incident under Unusual Operating Condition was declared. The procedures as per Section 5.2 of the OMS Plan were implemented with the evacuation of all personnel from within the Stage 1 Cofferdams. Due to the Unusual Operating Condition, the emergency preparedness procedures, in accordance with the Stage 1 Cofferdams – Emergency Response and Preparedness (ERP) Plan - PRHP-HS-PLA-000009 (PRHP 2017b), were also implemented to monitor the unusual operating condition and any potential affect it might have on the Stage 1 Cofferdams.

1.0 INSPECTION, SURVEILLANCE AND INSTRUMENTATION MONITORING

During the evening on November 29 and morning of November 30, visual inspections, site surveillance, survey confirmations and instrument monitoring commenced by PRHP and KP site personnel, in accordance with procedures set out in the OMS Plan (PRHP 2018a).

KP has reviewed all available data as provided on ADAS web-based instrumentation system, the survey data records provided by PRHP and site reports from PRHP and KP site representatives.

2.0 RE-CERTIFICATION OF STAGE 1 COFFERDAMS

KP agrees with the Type 2 Incident declaration due to this seismic event as an Unusual Operating Condition, as per the OMS Plan (PRHP 2018a).

Following KP's review of all available surveillance data and reports on the Stage 1 Cofferdams, KP can find no sign of any inherent damage caused by the seismic event of November 29, 2018 to any part of the Stage 1 Cofferdams.

KP herewith re-certify the Stage 1 Cofferdams to be fit for duty and safe for worker access/entry into the interior of the cofferdams. KP is of the opinion that all construction activities inside the Stage 1 Cofferdams can be reinstated/recommenced.

In the following 7 days, the Stage 1 Cofferdams should remain under heightened surveillance as a prudent safety precaution. Any unusual phenomena and/or conditions be captured in the weekly surveillance report and be reported to KP as soon as possible, these include:

- Unusual wet spots inside the cofferdam interiors
- Unusual seepage or flows into the cofferdam interiors
- Any cofferdam embankment crest settlements, slope slumps/failures and/or tension cracks, and
- Any turbidity noticed in seepage flows into the cofferdams.

Should you have any questions or require any further assistance on the above matter, please do not hesitate to contact the undersigned.

Yours truly,
Knight Piésold Ltd.



Prepared:

2018-11-30
Egbert Scherman, P. Eng.
Specialist Civil/Structural Engineer
Associate

Reviewed:



Sam Mottram, P. Eng.
Managing Principal, Power Services

Approval that this document adheres to the Knight Piésold Quality System:



Copy To: Mr. (19), (22) – Technical Director – Peace River Hydro Partners.
Mr. [REDACTED] – Dam Safety Incidents Presentative – BC Hydro

/ejs

REFERENCES

Peace River Hydro Partners (PRHP), PRHP 2017a. Stage 1 Cofferdams - Design Report. Ref: SCCEP-PRHP-ED-RPT-000001: Revision 4.

Peace River Hydro Partners (PRHP), PRHP 2018a. Stage 1 Cofferdams – Operations, Maintenance and Surveillance Plan. Ref: SCCEP-PRHP-QM-PLA-000003: Revision 3.

River Hydro Partners (PRHP), PRHP, PRHP 2017b. Site C Clean Energy Project Main Civil Works Emergency Response and Preparedness Plan. Ref: PRHP-HS-PLA-000009: Revision 0.

From: Watson, Andrew
Sent: 2019, January 28 9:53 AM
To: Schubak, Bob
Subject: FW: EQ of M=4.2, 15 km from Site C - PGA @ Sute ? (Was it OBE for the Site?)

fyi

From: (19), (22) [mailto:(19), (22)@snclavalin.com]
Sent: 2018, November 30 2:14 PM
To: Watson, Andrew; (19), (22)
Subject: FW: EQ of M=4.2, 15 km from Site C - PGA @ Sute ? (Was it OBE for the Site?)

FYI please

(19),
(22)

From: (19), (22)
Sent: November 30, 2018 12:56 PM
To: (19), (22)
Subject: EQ of M=4.2, 15 km from Site C - PGA @ Sute ? (Was it OBE for the Site?)

Hi all,

(22) was accompanied by a ground shaking near Site C. **An EQ of M=4.2 about 15 km from the site.** The PGA at the site would be different based on various attenuation curves but it could be **around 0.02 g**. If this is true, this could be close to the **1 in 475 year EQ** for the site or the **OBE (Operating Basis EQ)** for the site based on the following for Site C:

Earthquake Category for Dam and other Important Structures at Site C	Probability	PGA	Remarks
OBE (Operating Basis Earthquake)	1 in 475	0.022g	This is close to the November 29 EQ at FSJ, about 15 km from the site
DBE (Design Basis Earthquake)	1 in 2475	0.087g	
MDE (Maximum Design Earthquake) or MCE (Maximum Credible Earthquake)	1 in 10,000	0.25g	

We have been advised that, as expected, nothing adverse has been noted at the site. However (19), (22) is having a look at the instrumentation data to know any Change in the instrumentation data. Please do advise if someone has any further comments.

Regards,

(19),
(22)

From: Watson, Andrew
Sent: 2019, January 28 3:48 PM
To: Schubak, Bob
Cc: Venables, Stuart; Oswell, Terry; Johnson, Jeff
Subject: OGC contacts

Bob,
I have cc'ed Stuart and Jeff so you have their contact handy for the media request on earthquake.

Thx
Andrew

Andrew Watson, P.Eng., M.Eng.
Director, Design Engineering
Site C Clean Energy Project
BC Hydro
Suite 1200 745 Thurlow Street
Vancouver, BC V6E 4M3
Tel: 236-455-6715 (direct)
Cell (22) [REDACTED]

Web: www.sitecproject.com

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From: Addo, Kofi
Sent: 2018, November 30 8:30 AM
To: Schubak, Bob
Subject: Re: EQ last night in Fort St John

Bob,
There were 2 aftershocks following the main M4.5 event. The 5 km focal depth suggests it could be either natural or anthropogenic but likely the latter. Will take a closer look at the data later today.

Sent from my iPhone

On Nov 30, 2018, at 7:04 AM, Schubak, Bob <Bob.Schubak@bchydro.com> wrote:

Good morning Kofi,

I somehow suspect that you already know more about this than I do (☺) but just in case I thought I'd let you know that there was a M4.2 earthquake near FSJ yesterday evening.

Data:

Latitude	56.1685
Longitude	-120.5234
Depth	10 km

It was felt at the Site C construction site and work on the tunnels was shut down as a precaution until first light this morning.

The earthquake estimator (I know; these numbers won't be very good because the GMMs are wrong) suggested pga = 0.01g at Site C and 0.001g at PCN.

I'm not sure how rich or available the data will be from this event, but whatever you can get will be valuable, I think.

With the shallow depth, can we take the leap of logic to suggest this was likely the result of fracking or injection?

If you have an opinion, let me know, okay?

In any case, have a good and productive day.

See you next week.

Cheers,
Bob

Robert B. Schubak, Ph.D., P.Eng. | Director, Dam Safety

BC Hydro
6911 Southpoint Drive, 10th Floor
Burnaby, BC V3N 4X8

P 604 528 1680

M (22)

E bob.schubak@bchydro.com

bchydro.com

Smart about power in all we do.

From: (19), (22) @prhp.ca>
Sent: 2018, December 01 1:15 PM
To: Watson, Andrew: (19), (22); Abbey, Steven
Cc: McKenzie, Ken; (19), (22)
Schubak, Bob
Subject: Re: EQ response Thanks

Thanks Andrew,

It was a true teamwork success and we learnt a lot on the way, we will pass on the message.

Best,
(19), (22)

----- Original message -----

From: "Watson, Andrew" <Andrew.Watson@bchydro.com>
Date: 2018-12-01 11:22 AM (GMT-07:00)
To: (19), (22) @bchydro.com>, @bchydro.com>, @prhp.ca>
Cc: @bchydro.com>, @sncclavalin.com>, "McKenzie, Ken" <ken.mckenzie@bchydro.com>, @bchydro.com>, @prhp.ca>, "Schubak, Bob" <Bob.Schubak@bchydro.com>
Subject: EQ response Thanks

(19), (22)

Thanks for your role leading the response to the earthquake Thursday night. Pls pass on thx to others.

From my interactions you all showed strong leadership, coordination and communication between the groups. These unusual events are difficult given the speed needed for reaction with at times lack of information, schedule pressures and in this case first time for real event testing of some important procedures that impacted right across site. In this case folks were also heading home. These unusual events are very useful for understanding lessons learnt on ERP.

We appreciate the leadership to make sure safety was first and procedures executed to re-certify the cofferdams other other important inspections.

Thanks
Andrew

Sent from my iPhone

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From: (19), (22)
Sent: 2018, December 01 1:28 PM
To: Watson, Andrew; [redacted]
Cc: [redacted] McKenzie, Ken; Kahl, [redacted]
[redacted] Schubak, Bob
Subject: RE: EQ response Thanks

Totally agree, great teamwork and the message will be passed to all the participants.

Regards

(19), (22)

From: (19), (22) [redacted] @prhp.ca]
Sent: 2018, December 01 2:15 PM
To: Watson, Andrew; [redacted]
Cc: [redacted] McKenzie, Ken; [redacted] Schubak, Bob
Subject: Re: EQ response Thanks

Thanks Andrew,

It was a true teamwork success and we learnt a lot on the way, we will pass on the message.

Best,
(19), (22)

----- Original message -----

From: "Watson, Andrew" <Andrew.Watson@bchydro.com>
Date: 2018-12-01 11:22 AM (GMT-07:00)
To: [redacted] @bchydro.com>, [redacted] @bchydro.com> [redacted] @prhp.ca>
Cc: [redacted] @bchydro.com>, [redacted] nclavalin.com>, "McKenzie, Ken" <ken.mckenzie@bchydro.com>, [redacted] @bchydro.com>, [redacted] @bchydro.com>, [redacted] @prhp.ca>, "Schubak, Bob" <Bob.Schubak@bchydro.com>
Subject: EQ response Thanks

(19), (22)

Thanks for your role leading the response to the earthquake Thursday night. Pls pass on thx to others.

From my interactions you all showed strong leadership, coordination and communication between the groups. These unusual events are difficult given the speed needed for reaction with at times lack of information, schedule pressures and in this case first time for real event testing of some important procedures that impacted right across site. In this case folks were also heading home. These unusual events are very useful for understanding lessons learnt on ERP.

We appreciate the leadership to make sure safety was first and procedures executed to re-certify the cofferdams other other important inspections.

Thanks
Andrew

Sent from my iPhone

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From: (19), (22) [redacted]@prhp.ca>
Sent: 2018, November 29 7:45 PM
To: [redacted] Watson, Andrew
Cc: Schubak, Bob; [redacted]
Subject: RE: SiteC

Hello all,

ERP has been activated and we will keep our personnel outside from Cofferdams until tomorrow's daylight inspection.

Only piece of work that will keep going from PRHPs side for tonight is Adit 4 and the associated batch plant work.

Best,
(19), (22) [redacted]

From: Watson, Andrew <Andrew.Watson@bchydro.com>
Sent: November-29-18 8:21 PM
To: (19), (22) [redacted]@bchydro.com>
Cc: Schubak, Bob <Bob.Schubak@bchydro.com>; [redacted]@prhp.ca> [redacted]
[redacted]@bchydro.com> [redacted]@bchydro.com>
Subject: Re: SiteC

Th (19), (22) [redacted]

I understand from Paul Oblander they are keeping everyone out till they can also do a visual first light and confirm instrument readings

Andrew

Sent from my iPhone

On Nov 29, 2018, at 7:17 PM, (19), (22) [redacted]@bchydro.com> wrote:

See below. We can't see the data yet, but Wally has.
No reading jumps on the Right Bank Cofferdam.

We'll look at the data in detail when we get access around 8:00.

(19), (22) [redacted]

From: Wally Kobetitch [<mailto:wkobetitch@rstinstruments.com>]
Sent: 2018, November 29 7:15 PM
To: (22), (19) [redacted]
Subject: SiteC

The 20:00 (MT) data has all come in – no new warnings or alarms.
Going through all plots to see if any influences show up.

RST Instruments Ltd., per
Wally Kobetitch, A.Sc.T.
Instrumentation Specialist
Tel: 250.850.9054
Email: wkobetitch@rstinstruments.com
Web: www.rstinstruments.com

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From: McKenzie, Ken
Sent: 2018, November 30 4:26 PM
To: DL - Site C Staff
Cc: O'Riley, Christopher; Clarke, Gareth; Fenwick, Graham; Schubak, Bob
Subject: RE: Update on Earthquake near Fort St. John

Good afternoon,

To follow up on my earlier email, the detailed inspections of each area are now complete and we've confirmed that there was no damage to structures or equipment as a result of yesterday's earthquake.

Work in all project areas has safely resumed.

Thank you,

Ken

From: McKenzie, Ken
Sent: 2018, November 30 11:27 AM
To: DL - Site C Staff
Cc: O'Riley, Christopher; Clarke, Gareth; Fenwick, Graham; Schubak, Bob
Subject: Update on Earthquake near Fort St. John

Good morning,

Yesterday evening, a magnitude ~4.2 earthquake occurred in northeastern B.C., not far from Fort St. John and the Site C project site.

Our top priority, as always, is the safety of our workers and members of the public. I'm pleased to confirm that no employees or contractors were injured as a result of this event.

Immediately following the earthquake, our safety response procedures were implemented. This included the evacuation of workers from areas of the project site that were potentially at risk – such as within the Diversion Tunnels, Right Bank Drainage Tunnel, and in lower elevation areas along the river.

Based on an initial assessment (visually and through our monitoring equipment), no impacts to equipment or structures on site have been reported. To be thorough, we are working with our contractors to conduct a full site inspection, which is currently underway.

Out of an abundance of caution, we're keeping workers away from certain areas of the dam site, including the areas I mentioned above, until a detailed inspection of each area is complete. Work continues as planned in all other project areas.

I'll share more information with you once we know more. In the meantime, thank you for your patience and cooperation as we complete the inspections, and thank you for continuing to work safely.

Ken

Ken McKenzie, P. Eng., MBA
EVP, Site C Clean Energy Project

BC Hydro

T [604 528 2617](tel:6045282617)

M (22)

F [604 528 2547](tel:6045282547)

E Ken.Mckenzie@bchydro.com

From: O'Riley, Christopher
Sent: 2018, November 30 6:59 AM
To: Schubak, Bob
Cc: Daschuk, Maureen
Subject: Re: DC Initial and Final Report M 4.2 Earthquake - No Reported Impacts to BCH
Attachments: image001.jpg

Thanks. I did hear that OGC were following up.

Sent from my iPhone

On Nov 30, 2018, at 6:56 AM, Schubak, Bob <Bob.Schubak@bchydro.com> wrote:

I really have no idea about that, Chris.
I did hear on the radio this morning that the OGC is looking into it.
The focal depth of the earthquake is reported to be 10 km, which is pretty shallow, so that might be an indicator of it being induced rather than natural.
I'm about as far away from being an expert on the subject of induced seismicity as you can get.

Kofi Addo will be all over the records from this event once they're available as they'll be very valuable to his current work on developing ground motion models for fracking/injection well earthquakes.
Once he's had a chance to look at the data I'll ask him for his assessment and relay the information to you and Maureen.

I'm glad that no harm came of things last night.

Bob

Robert B. Schubak, Ph.D., P.Eng. | Director, Dam Safety

BC Hydro
6911 Southpoint Drive, 10th Floor
Burnaby, BC V3N 4X8

P 604 528 1680
M (22) [REDACTED]
E bob.schubak@bchydro.com

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From: O'Riley, Christopher
Sent: 2018, November 30 6:13 AM
To: Schubak, Bob
Cc: Daschuk, Maureen
Subject: Fwd: DC Initial and Final Report M 4.2 Earthquake - No Reported Impacts to BCH

Bob, is there any indication this was related to fracking?

Sent from my iPhone

Begin forwarded message:

From: Duty Coordinator <DutyCoordinator@bchydro.com>

Date: November 29, 2018 at 9:31:50 PM PST

To: "O'Riley, Christopher" <Chris.Oriley@bchydro.com>, "Poweska, Mark" <Mark.Poweska@bchydro.com>, "Lebeter, David" <david.lebeter@bchydro.com>, "Fraser, Janet" <Janet.Fraser@bchydro.com>, "Wong, David" <David.Wong@bchydro.com>, "Daschuk, Maureen" <Maureen.Daschuk@bchydro.com>, "Leonard, Allan" <Allan.Leonard@bchydro.com>, "Lings, Raymond" <Raymond.Lings@powertechlabs.com>, "Bechard, Thomas" <Tom.Bechard@powerex.com>, "Sauer, Darwin" <Darwin.Sauer@bchydro.com>, "Young, Brandon" <Brandon.Young@bchydro.com>

Cc: "Schubak, Bob" <Bob.Schubak@bchydro.com>, Duty Coordinator <DutyCoordinator@bchydro.com>, "Sofield, Joanna" <Joanna.Sofield@bchydro.com>, "Sawchuck, Lanny" <Lanny.Sawchuck@bchydro.com>, "Brittin, Richard" <Richard.Brittin@bchydro.com>, "Kroeker, Murray" <Murray.Kroeker@bchydro.com>, "Prestwich, Mark" <Mark.Prestwich@bchydro.com>, "Burkitt, Stanlan" <Stanlan.Burkitt@bchydro.com>, "Weyell, Chris" <Chris.Weyell@bchydro.com>

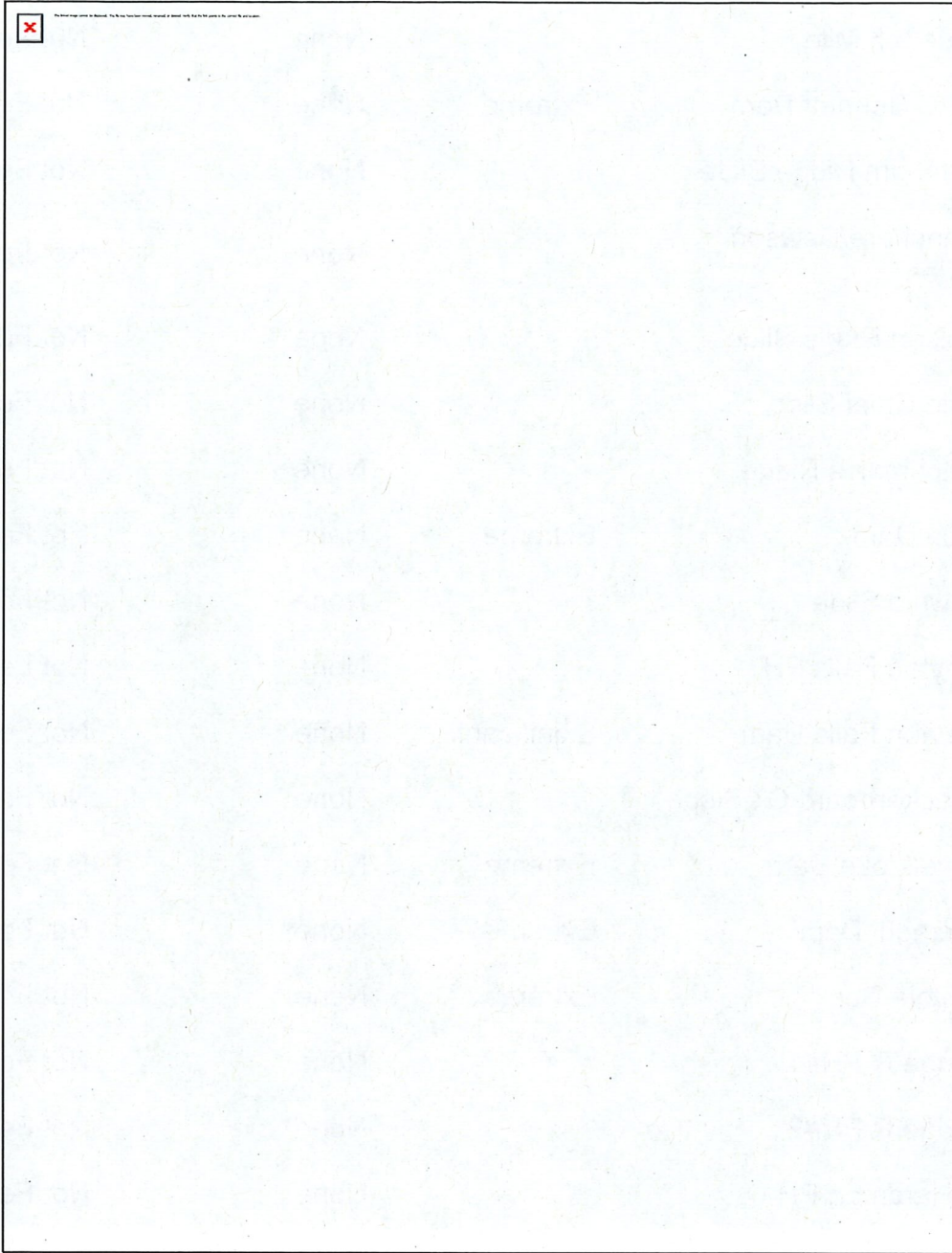
Subject: DC Initial and Final Report M 4.2 Earthquake - No Reported Impacts to BCH

A 4.2 M earthquake took place at around 5:45 tonight, 22 km ESE of Fort St. John.

Emergency protocols were followed and key internal stakeholders have confirmed no damage to hydro plants and no reported outages on our system. One customer near Septimus reported an outage on their equipment.

The Community Relations Manager received an inquiry from local media. CBC and Global News are reporting the earthquake.

Below is a map of the epicentre. Red pins are dams, black pins are substations, purple pins are buildings.



Reports from the Earthquake Estimating App:

Below is a list of the perceived shaking and potential damage at the closest dams:

Dam	Consequence	Potential Damage	Perceived Shaking	Dist EPI
Site C Dam	High	None	Weak	24.
Peace Canyon Dam	Very High	None	Not Felt	93.

Slide 3.5 Mile		None	Not Felt	98
WAC Bennett Dam	Extreme	None	Not Felt	10
Branham Ridge Slide		None	Not Felt	13
Franchere/Dawson Slides		None	Not Felt	45
Molson Ridge Slide		None	Not Felt	46
Little Chief Slide		None	Not Felt	46
Dutchman's Ridge		None	Not Felt	47
Mica Dam	Extreme	None	Not Felt	47
Downie Slide		None	Not Felt	53
Clayton Falls PH		None	Not Felt	58
Clayton Falls Dam	Significant	None	Not Felt	58
Checkerboard Ck Slope		None	Not Felt	58
Revelstoke Dam	Extreme	None	Not Felt	58
Terzaghi Dam	Extreme	None	Not Felt	60
La Joie Dam	Extreme	None	Not Felt	61
Bridge R PH#1		None	Not Felt	61
Bridge R PH#2		None	Not Felt	61
W.Hardman PH		None	Not Felt	61

Below is a list of the perceived shaking at the closest towns and cities:

Town or City	Potential Damage	Perceived Shaking	Distance to EPI (km)	Latitude	Longitude
Taylor	None	Light	9.9	56.1667	-119.1667
Ft. St. John	None	Weak	22.1	56.2500	-119.1667
Charlie Lake	None	Weak	32.4	56.2667	-119.1667

					1
Dawson Creek	None	Weak	48.2	55.7667	-1
Pouce Coupe	None	Weak	55.8	55.7167	-1
Moberly Lake	None	Not Felt	84.0	55.8333	-1
Hudson's Hope	None	Not Felt	87.0	56.0167	-1
Kelly Lake	None	Not Felt	107.0	55.2500	-1
Chetwynd	None	Not Felt	147.5	55.0000	-1
Mackenzie	None	Not Felt	186.1	55.3167	-1
Bear Lake	None	Not Felt	232.8	54.4667	-1
Aleza lake	None	Not Felt	248.3	54.1167	-1
Sinclair Mills	None	Not Felt	250.4	54.0167	-1
Prince George	None	Not Felt	287.7	53.9167	-1
Ft. St. James	None	Not Felt	303.5	54.4500	-1
Old Fort Nelson	None	Not Felt	318.4	58.8167	-1
McBride	None	Not Felt	319.6	53.3000	-1
Fort Nelson	None	Not Felt	322.3	58.8167	-1
Vanderhoof	None	Not Felt	326.5	54.0167	-1
Fort Fraser	None	Not Felt	346.6	54.0667	-1

Below is a list of the perceived shaking and potential damage at the closest substations:

Substation	Component	Potential Damage	Perceived Shaking	Dist EPI
FBC	FIBERCO (CANFOR TAYLOR) SUB	None	Light	8.6
NGL	TAYLOR (SOLEX) GAS SUB	None	Light	9.2
MCM	MCMAHON COGEN	None	Light	9.3
MGP	MCMAHON GAS SUB	None	Light	9.4
TAY	TAYLOR SUB	None	Light	12.
FJN	FORT ST. JOHN SUB	None	Weak	19.
ET3	ENCANA TOWER 3-7-81-17W6	None	Weak	20.
SEP	CNRL SEPTIMUS SUB	None	Weak	26.
TXB	BOUNDARY LAKE SUB	None	Weak	30.
KIS	KISKATINAW 15-27-W5	None	Weak	32.
KIS	KISKATINAW SUB	None	Weak	32.
BMT	BEAR MOUNTAIN TERMINAL	None	Weak	45.
DAW	DAWSON CREEK SUB	None	Weak	46.
BMW	BEAR MOUNTAIN WIND SUB	None	Weak	52.
SGB	SHELL GROUNDBIRCH SWITCH	None	Not Felt	60.
FOX	FOX CREEK SUB	None	Not Felt	63.
LAP	CHETWYND MECH PULP (LOUISIANA PAC) SUB	None	Not Felt	67.
SLS	SUNDANCE LAKES SUB	None	Not Felt	72.
NL5	NODE 5 COMPRESSOR SUB	None	Not Felt	84.
CWD	CHETWYND SUB	None	Not Felt	86.

Below is a list of the perceived shaking and potential damage at the closest buildings:

BCH Number	Building	Potential Damage	Perceived Shaking	Distance to EPI (km)	Maintained By	City
BCH017	Fort St. John	None	Weak	21.1	BC Hydro Properties	Fort St. John
BCH016	Dawson Creek	None	Weak	47.2	BC Hydro Properties	Dawson Creek
BCH015	Chetwynd	None	Not Felt	86.2	BC Hydro Properties	Chetwynd
BCH020	Mackenzie	None	Not Felt	185.6	BC Hydro Properties	Mackenzie
BCH114	Prince George Vehicle Garage	None	Not Felt	290.1	BGIS	Prince George
BCH022	Prince George Nicholson Building	None	Not Felt	290.3	BGIS	Prince George
BCH127	Prince George	None	Not Felt	290.3	BGIS	Prince George
BCH029	Fort Nelson	None	Not Felt	319.7	BC Hydro Properties	Fort Nelson
BCH027	Vanderhoof	None	Not Felt	327.0	BC Hydro Properties	Vanderhoof
BCH024	Quesnel	None	Not Felt	375.9	BC Hydro Properties	Quesnel
BCH044	Valemount	None	Not Felt	378.9	BC Hydro Properties	Valemount
BCH014	Burns Lake	None	Not Felt	395.9	BC Hydro Properties	Burns Lake
BCH025	Smithers	None	Not Felt	444.8	BC Hydro Properties	Smithers
BCH018	New	None	Not Felt	454.3	BC Hydro	New

	Hazelton				Properties	Hazelton
BCH028	Williams Lake	None	Not Felt	460.3	BC Hydro Properties	Williams Lake
BCH031	Clearwater	None	Not Felt	503.0	BC Hydro Properties	Clearwater
BCH036	Hundred Mile House	None	Not Felt	506.4	BC Hydro Properties	Hundred Mile House
BCH026	Terrace	None	Not Felt	544.0	BGIS	Terrace
BCH019	Kitimat	None	Not Felt	564.8	BC Hydro Properties	Kitimat
BCH103	Stewart	None	Not Felt	587.2	BC Hydro Properties	Stewart

This is the final report pending any new information.

Chris Weyell (Duty Coordinator)
Brandee Clayton (Duty Emergency Manager)

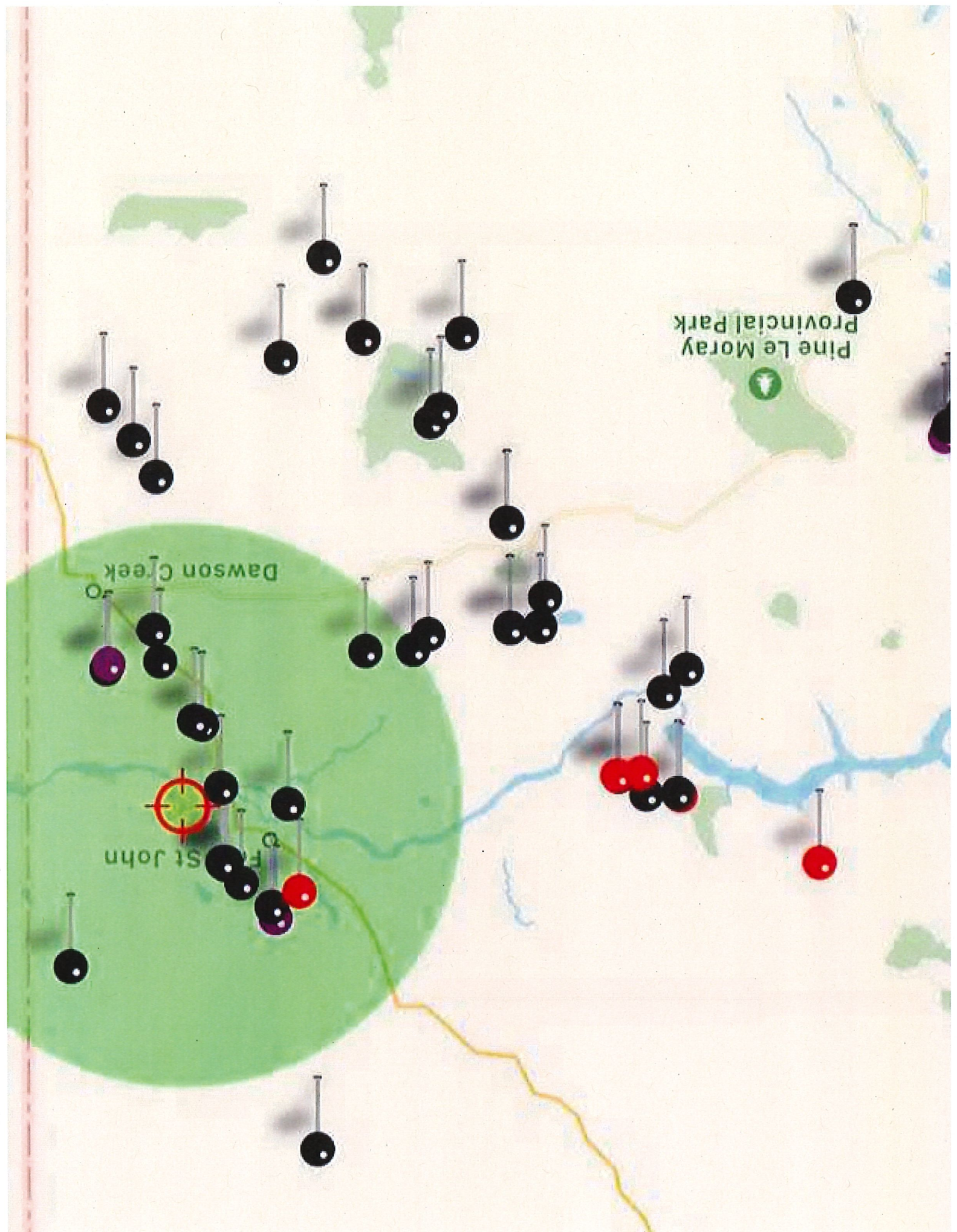
Duty Coordinator

BC Hydro

T 1 877 311 8611

E dutycoordinator@bchydro.com

bchydro.com



From: Brittin, Richard
Sent: 2018, November 29 9:59 PM
To: Schubak, Bob
Subject: Re: 2018-11-30 01:27:06 (M4.2) British Columbia, Canada 56.2 -120.5 (9856c)

Thanks Bob

Richard Brittin, P.Eng. | Director - Stations Field Operations

BC Hydro
[6911 Southpoint Drive, 18th floor](#)
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M (22) [REDACTED]
E richard.brittin@bchydro.com

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On Nov 29, 2018, at 8:36 PM, Schubak, Bob <Bob.Schubak@bchydro.com> wrote:

Hi Richard. I did. Sorry I missed your email until now.
It's all good. No alarms or issues at PCN or GMS. Site C experienced about 1%g acceleration (very low) and the instrumentation is being checked by the Site C team. I don't expect there to be any issues there.
Cheers
Bob

Robert B. Schubak, Ph.D., P.Eng.
Director, Dam Safety
BC Hydro
P | 604-528-1680
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E | bob.schubak@bchydro.com

On Nov 29, 2018, at 6:18 PM, Brittin, Richard <Richard.Brittin@bchydro.com> wrote:

Bob
This is from the auto notification for seismic events. Did you get this? Do we need to take any action?

Thanks
RB

Richard Brittin, P.Eng. | Director - Stations Field Operations

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Begin forwarded message:

From: USGS ENS <ens@ens.usgs.gov>
Date: November 29, 2018 at 5:50:16 PM PST
To: <richard.brittin@bchydro.com>
Subject: 2018-11-30 01:27:06 (M4.2) British Columbia, Canada
56.2 -120.5 (9856c)
Reply-To: <ens@ens.usgs.gov>

M4.2 Earthquake - British Columbia, Canada

Preliminary Report

Magnitude	4.2
Date-Time	<ul style="list-style-type: none">• 30 Nov 2018 01:27:07 UTC• 29 Nov 2018 18:27:07 near epicenter• 29 Nov 2018 17:27:07 standard time in your timezone
Location	56.169N 120.523W
Depth	10 km
Distances	<ul style="list-style-type: none">• 22.4 km (13.9 mi) ESE of Fort St. John, Canada• 48.8 km (30.3 mi) NNW of Dawson Creek, Canada• 155.4 km (96.4 mi) NW of Grande Prairie, Canada• 288.3 km (178.8 mi) NNE of Prince George, Canada• 538.3 km (333.8 mi) WNW of Edmonton, Canada

Location Uncertainty Horizontal: 4.0 km; Vertical 1.9 km

Parameters Nph = 55; Dmin = 103.4 km; Rmss = 1.34 seconds; Gp = 46°
Version =

Event ID us 1000hy6d

For updates, maps, and technical information
see: [Event Page](#) or [USGS Earthquake Hazards Program](#)
National Earthquake Information Center

U.S. Geological Survey

Disclaimer

This email was sent to richard.brittin@bchydro.com

You requested mail for events within the 'BC and offshore' region for M3.0 at all times.

To change your parameters, go to: <https://earthquake.usgs.gov/ens>

To unsubscribe, send a one-line reply to this message with: STOP
richard.brittin@bchydro.com

From: Venables, Stuart <Stuart.Venables@BCOGC.ca>
Sent: 2019, January 29 11:13 AM
To: Schubak, Bob; Johnson, Jeff
Cc: Watson, Andrew; Oswell, Terry
Subject: RE: Media request: November Peace River Region earthquake
Attachments: Site C Media draft for review_OGC.docx

Morning Bob,

We made one (very) minor change to the answer in question 4. Otherwise, everyone felt that BC Hydro did a great job with the responses. Thank you for providing this information to us to review, it's really appreciated. Lannea Parfitt from our Communications team may reach out to Kevin Aquino from your Communications team to get more background details.

Thanks again and have a great day,

-Stu



Stuart Venables P.Geo
Senior Petroleum Geologist
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From: Schubak, Bob <Bob.Schubak@bchydro.com>
Sent: Monday, January 28, 2019 4:54 PM
To: Venables, Stuart <Stuart.Venables@BCOGC.ca>; Johnson, Jeff <Jeff.Johnson@bcogc.ca>
Cc: Watson, Andrew <Andrew.Watson@bchydro.com>; Oswell, Terry <Terry.Oswell@bchydro.com>
Subject: FW: Media request: November Peace River Region earthquake

Good evening Stuart and Jeff,
I hope you are both well.

BC Hydro has recently received a request from a person in the media for answers to questions regarding the November 29, 2018 earthquake near Fort St. John. The reporter is writing his piece following the provincial Oil and Gas Commission ordering the natural gas company suspected of triggering that earthquake to cease operations, along with other natural gas companies.

We've drafted a response to those questions, attached, but as a number of them pertain to directives that have been established by the OGC we were hoping that you might look at our responses and correct any factual errors we may have inadvertently made. If this is not something for which you have the time or inclination, please don't hesitate to respond to that effect and we'll respond with what we have.

Thanks gents. I look forward to future meetings and discussions.

Regards,
Bob

Robert B. Schubak, Ph.D., P.Eng. | Director, Dam Safety

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M (22)

E bob.schubak@bchydro.com

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From: Aquino, Kevin
Sent: 2019, January 24 4:10 PM
To: Schubak, Bob; Ahlfield, Kay
Subject: Media request: November Peace River Region earthquake

Hi Bob, Kay – hope all is well. We received a media request about the late November earthquake that was felt in the Peace River region and subsequently at Site C. The reporter is writing his piece following the provincial Oil and Gas Commission ordering the natural gas company suspected of triggering that earthquake to cease operations, along with other natural gas companies.

Here are his list of questions verbatim. He wanted to know if BC Hydro:

1. Was 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?
2. Expressed 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?
3. Conducted any site inspections at the Site C site following the earthquake to determine whether any damage may have occurred?
4. Has 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?
5. Considers 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?
6. Has 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.
7. Regularly receives information from third parties (for example natural gas companies) about what their seismographs detect by way of ground motion?

Kevin Aquino | Media Relations & Issues Management

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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 **extracting gas from 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 Natural Resources 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.

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<Site C Media draft for review.docx>

From: Addo, Kofi
Sent: 2019, January 28 9:08 AM
To: Aquino, Kevin; Schubak, Bob
Cc: Watson, Andrew; (19), (22) [redacted] Oswell, Terry; Ahlfield, Kay
Subject: RE: Media request: November Peace River Region earthquake
Attachments: Nov29EarthquakeMediaRequest.docx

As requested, my comments are in the attached document.

From: Aquino, Kevin
Sent: 2019, January 28 8:46 AM
To: Schubak, Bob; Watson, Andrew; (19), (22) [redacted] Ahlfield, Kay; Oswell, Terry; Addo, Kofi
Subject: RE: Media request: November Peace River Region earthquake

Thanks for the update, Bob. I appreciate it.

From: Schubak, Bob
Sent: 2019, January 28 6:55 AM
To: Watson, Andrew; (19), (22) [redacted] Ahlfield, Kay; Oswell, Terry; Addo, Kofi
Cc: Aquino, Kevin
Subject: Media request: November Peace River Region earthquake

Good morning all,

I hope you had a good weekend.

Thanks to all of you for providing your inputs to the questions posed by a member of the media on Friday regarding the Nov 29 earthquake near Fort St. John.

I've compiled your responses and the notes that I had taken during meetings into a single set of answers, **below**. Please try to give these a read and bring any concerns you have to my attention.

I've scheduled a telephone call with Andrew for this afternoon (I hope that works for you, Andrew) to go over the answers and make sure they're correct and ready to send back to Kevin Aquino (cc'd).

Thanks,
Bob

Robert B. Schubak, Ph.D., P.Eng. | Director, 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 and indefinitely suspended.

A subsequent teleconference was held on December 11, 2018 at the Commission’s request, their goal being to understand upcoming activities on the Site C project in relation to proposed drilling and well completion by Crew Energy within the 5 kilometer buffer zone of Site C. BC Hydro described what actions would be taken on site in response to a felt event, as documented in the project contractor’s plans. BC Hydro also provided a description of how the November 29 event was felt on site.

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, and personnel were evacuated from areas behind the cofferdams. No injuries were sustained on site as a result of 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 extracting gas from 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 exclusion 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. There is no basis, at this time, for BC Hydro to consider that this zone needs to be extended further out.

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 Natural Resources 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.

The Commission has put into place a requirement that any existing tenure holder within 5 km of WAC Bennett, Peace Canyon or Site C dam must notify BC Hydro of drilling and completion activities planned to take place within those zones. 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. 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: Aquino, Kevin
Sent: 2019, February 21 10:09 AM
To: Schubak, Bob
Subject: RE: Media request: November Peace River Region earthquake
Attachments: Site C Media response.docx

Hi Bob – hope all is well.

We received one follow up question on this request. The reporter was hoping to find out where meetings were held between BC Hydro, and the OGC and Crew Energy. The meeting between BC Hydro and the OGC was over a telephone conference, but are you able to tell me where the meeting was held with Crew Energy?

Thanks in advance,
Kevin

From: Schubak, Bob
Sent: 2019, January 29 12:23 PM
To: Aquino, Kevin
Subject: FW: Media request: November Peace River Region earthquake

Kevin,
Here's the response that was prepared by Dam Safety and Site C and vetted for accuracy by the OGC.
Now it's time for media relations to do it's thing, I guess.
Thanks,
Bob

Robert B. Schubak, Ph.D., P.Eng. | Director, Dam Safety

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From: Venables, Stuart [mailto:Stuart.Venables@BCOGC.ca]
Sent: 2019, January 29 11:13 AM
To: Schubak, Bob; Johnson, Jeff
Cc: Watson, Andrew; Oswell, Terry
Subject: RE: Media request: November Peace River Region earthquake

Morning Bob,

We made one (very) minor change to the answer in question 4. Otherwise, everyone felt that BC Hydro did a great job with the responses. Thank you for providing this information to us to review, it's really appreciated. Lannea Parfitt from our Communications team may reach out to Kevin Aquino from your Communications team to get more background details.

Thanks again and have a great day,

-Stu



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From: Schubak, Bob <Bob.Schubak@bchydro.com>
Sent: Monday, January 28, 2019 4:54 PM
To: Venables, Stuart <Stuart.Venables@BCOGC.ca>; Johnson, Jeff <Jeff.Johnson@bcogc.ca>
Cc: Watson, Andrew <Andrew.Watson@bchydro.com>; Oswell, Terry <Terry.Oswell@bchydro.com>
Subject: FW: Media request: November Peace River Region earthquake

Good evening Stuart and Jeff,
I hope you are both well.

BC Hydro has recently received a request from a person in the media for answers to questions regarding the November 29, 2018 earthquake near Fort St. John. The reporter is writing his piece following the provincial Oil and Gas Commission ordering the natural gas company suspected of triggering that earthquake to cease operations, along with other natural gas companies.

We've drafted a response to those questions, attached, but as a number of them pertain to directives that have been established by the OGC we were hoping that you might look at our responses and correct any factual errors we may have inadvertently made. If this is not something for which you have the time or inclination, please don't hesitate to respond to that effect and we'll respond with what we have.

Thanks gents. I look forward to future meetings and discussions.

Regards,
Bob

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From: Aquino, Kevin
Sent: 2019, January 24 4:10 PM
To: Schubak, Bob; Ahlfield, Kay
Subject: Media request: November Peace River Region earthquake

Hi Bob, Kay – hope all is well. We received a media request about the late November earthquake that was felt in the Peace River region and subsequently at Site C. The reporter is writing his piece following the provincial Oil and Gas Commission ordering the natural gas company suspected of triggering that earthquake to cease operations, along with other natural gas companies.

Here are his list of questions verbatim. He wanted to know if BC Hydro:

1. Was 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?
2. Expressed 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?
3. Conducted any site inspections at the Site C site following the earthquake to determine whether any damage may have occurred?
4. Has 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?
5. Considers 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?
6. Has 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.
7. Regularly receives information from third parties (for example natural gas companies) about what their seismographs detect by way of ground motion?

Kevin Aquino | Media Relations & Issues Management

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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 Natural Resources 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: McKenzie, Ken
Sent: 2018, November 30 11:27 AM
To: DL - Site C Staff
Cc: O'Riley, Christopher; Clarke, Gareth; Fenwick, Graham; Schubak, Bob
Subject: Update on Earthquake near Fort St. John

Good morning,

Yesterday evening, a magnitude ~4.2 earthquake occurred in northeastern B.C., not far from Fort St. John and the Site C project site.

Our top priority, as always, is the safety of our workers and members of the public. I'm pleased to confirm that no employees or contractors were injured as a result of this event.

Immediately following the earthquake, our safety response procedures were implemented. This included the evacuation of workers from areas of the project site that were potentially at risk – such as within the Diversion Tunnels, Right Bank Drainage Tunnel, and in lower elevation areas along the river.

Based on an initial assessment (visually and through our monitoring equipment), no impacts to equipment or structures on site have been reported. To be thorough, we are working with our contractors to conduct a full site inspection, which is currently underway.

Out of an abundance of caution, we're keeping workers away from certain areas of the dam site, including the areas I mentioned above, until a detailed inspection of each area is complete. Work continues as planned in all other project areas.

I'll share more information with you once we know more. In the meantime, thank you for your patience and cooperation as we complete the inspections, and thank you for continuing to work safely.

Ken

Ken McKenzie, P. Eng., MBA
EVP, Site C Clean Energy Project

BC Hydro

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From: Duty Coordinator
Sent: 2018, November 30 9:31 AM
To: O'Riley, Christopher; Poweska, Mark; Lebeter, David; Fraser, Janet; Wong, David; Daschuk, Maureen; Leonard, Allan; Lings, Raymond; Bechard, Thomas; Sauer, Darwin; Young, Brandon
Cc: Schubak, Bob; Duty Coordinator; Sofield, Joanna; Sawchuck, Lanny; Brittin, Richard; Kroeker, Murray; Prestwich, Mark; Burkitt, Stanlan; Weyell, Chris; Abbey, Steven; Taylor, Fiona; Mason, Shanna; Alexis, Greg; Scott, Mora
Subject: Update to DC Final Report M 4.2 Earthquake - No Reported Impacts to BCH

Please find below an update on the M 4.2 earthquake that took place last night, 22 km ESE of Fort St. John.

Update on Media regarding Site C:

Last night Global and the Alaska Highway News inquired about Site C. BC Hydro provided the following information:

- There were no injuries at the Site C dam, but we have deployed a team to inspect the site for damage or impact to operations. Any impact won't be clear until the morning when crews can make use of daylight. There were no immediate reports of serious damage.

Update from Site C:

No impacts are reported. Site is currently completing their emergency procedures and inspections before allowing all work to continue.

This is the final report.

Chris Weyell (Duty Coordinator)
Brandee Clayton (Duty Emergency Manager)

Duty Coordinator

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