

1 Q. **Reference: Schedule 1 – Upgrade Report – Penstock 1 Life Extension – Bay d'Espoir.**

2 Please detail the progression of findings as to the cause of the failures starting with the first  
3 failure in 2016 and ending with the conclusion as stated on page i, lines 18-19, “the root cause  
4 of the cracking found in the penstocks was high stresses in the longitudinal weld seams due to  
5 “peaking”, which is further exacerbated by corrosion and cyclic stresses.”

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8 A. A summary of the reports issued by Newfoundland and Labrador Hydro’s consultants that detail  
9 the progression of findings related to the root causes of the penstock rupture is provided herein.  
10 For a comprehensive explanation of the findings, please refer to the referenced reports.

11 • **“Crack Investigation and Repair Report – Penstock No. 1 Bay d'Espoir Hydroelectric**  
12 **Development,” Kleinschmidt, June 2016<sup>1</sup>**

13 The cause of the May 2016 rupture was suspected to be a local defect in the material or the  
14 weld, caused by either material incompatibility, improper welding procedure, or location-  
15 specific weld error. It was noted that this crack could have been further propagated by  
16 water-up/dewatering cycles.

17 • **“Root Cause Analysis Report for Bay d'Espoir Penstock No. 1 Refurbishment,” Hatch Ltd.,**  
18 **March 17, 2017<sup>2</sup>**

19 The root cause of the September 2016 rupture was assessed to be high stress  
20 concentrations in the longitudinal joint. The high stress concentrations were noted to be  
21 influenced by factors such as corrosion, reduced material thickness in the heat-affected  
22 zone, and lack of backfill support. A preliminary review of the backfill profile had indicated

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<sup>1</sup> “Application for Approval of Capital Expenditures for Section Replacement and Weld Refurbishment for Bay d'Espoir Hydroelectric Generating Facility Penstock 1,” Newfoundland and Labrador Hydro, December 7, 2022, sch. 1, app. A.

<sup>2</sup> “Application for Approval of Capital Expenditures for Section Replacement and Weld Refurbishment for Bay d'Espoir Hydroelectric Generating Facility Penstock 1,” Newfoundland and Labrador Hydro, December 7, 2022, sch. 1, app. B.

1           this may be influencing the penstock's performance. A detailed study was recommended  
2           and undertaken.

- 3           • **“Final Report for the Bay d’Espoir Penstock No. 1 Stress Analyses,” Hatch Ltd.,**  
4           **March 20, 2017<sup>3</sup>**

5           This report provided a further study on penstock loads and stresses, most significantly a  
6           finite element model analyzing the impact of the backfill profile on the penstock. This study  
7           determined that the backfill profile provided important support to the penstock in certain  
8           load cases.

- 9           • **“Final Report for Repair and Failure Investigation,” Hatch Ltd., May 17, 2018<sup>4</sup>**

10          This was an extensive investigation following the November 2017 rupture, which assessed  
11          that this failure was due to residual stresses in the steel when previously repaired in  
12          September 2016, high-localized stresses due to the "peaking" of the penstock at the weld  
13          seams, and fatigue due to the operation of the generating units inducing cyclic stresses. This  
14          report further noted that the backfill stresses identified in the “Final Report for the Bay  
15          d’Espoir Penstock No. 1 Stress Analyses,” Hatch Ltd., March 20, 2017 impacted the penstock  
16          when dewatered but were of marginal impact when the penstock was operational. As such,  
17          the backfill was unlikely to be the root cause of the ruptures. To understand their condition,  
18          a comprehensive condition assessment of all three penstocks was recommended.  
19          Additionally, operating restrictions were placed on Units 1 and 2 following this report in  
20          order to limit the amount of time traveled through the “rough zone.” Operation in the rough  
21          zone generates cyclic stresses in the penstock. For further discussion of the operating  
22          restrictions implemented, please refer to Hydro’s response to PUB-NLH-005 of this  
23          proceeding.

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<sup>3</sup> “Application for Approval of Capital Expenditures for Section Replacement and Weld Refurbishment for Bay d’Espoir Hydroelectric Generating Facility Penstock 1,” Newfoundland and Labrador Hydro, December 7, 2022, sch. 1, app. C.

<sup>4</sup> “Application for Approval of Capital Expenditures for Section Replacement and Weld Refurbishment for Bay d’Espoir Hydroelectric Generating Facility Penstock 1,” Newfoundland and Labrador Hydro, December 7, 2022, sch. 1, app. D.

- 1           • **“Final Report for Condition Assessment and Refurbishment Options for Penstocks No. 1, 2**  
2           **and 3,” Hatch Ltd., March 28 2019<sup>5</sup> and “Final Report for Penstock No.’s 1. 2 and 3 Life**  
3           **Extension,” Hatch Ltd., July 26, 2019<sup>6</sup>**

4           These reports further confirmed the assessment that high local stresses at the weld seams,  
5           exacerbated by corrosion and fatigue from cyclic stresses, were the root cause of the recent  
6           penstock ruptures. While Hatch Ltd. (“Hatch”) believed the recent remedial work had  
7           helped to stabilize the penstocks, they recommended annual inspections and the deferral of  
8           work on the backfill until life extension work could be completed within the next 3 to  
9           5 years.

- 10          • **“Bay d'Espoir Penstock No. 1 – 2019 Failure Investigation Report,” SNC-Lavalin,-March**  
11          **19, 2020<sup>7</sup>**

12          Following the September 2019 rupture, SNC-Lavalin was engaged to provide a "cold eyes"  
13          review of the work completed on Penstock 1 to date, as well as an independent assessment  
14          of the most recent rupture. SNC-Lavalin reached the same conclusion as Hatch regarding the  
15          root cause of the penstock ruptures. The determination was that high-localized stresses  
16          present at the weld seams, in combination with corrosion, have been the source of the  
17          penstock ruptures.

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<sup>5</sup> “Application for Approval of Capital Expenditures for Section Replacement and Weld Refurbishment for Bay d'Espoir Hydroelectric Generating Facility Penstock 1,” Newfoundland and Labrador Hydro, December 7, 2022, sch. 1, app. H.

<sup>6</sup> “Application for Approval of Capital Expenditures for Section Replacement and Weld Refurbishment for Bay d'Espoir Hydroelectric Generating Facility Penstock 1,” Newfoundland and Labrador Hydro, December 7, 2022, sch. 1, app. I.

<sup>7</sup> “Application for Approval of Capital Expenditures for Section Replacement and Weld Refurbishment for Bay d'Espoir Hydroelectric Generating Facility Penstock 1,” Newfoundland and Labrador Hydro, December 7, 2022, sch. 1, app. F.