Q. Please provide Hydro's assessments for the LIL related to the possibility (e.g., low, medium, or high) for each of the events listed below to be capable of causing the LIL to be non-operational for an extended period of time:

a) extreme weather;

b) line or terminal station equipment failure;

c) vandalism;

d) cybersecurity attack; and

e) other possible but likely less probable events such as an earthquake or airplane hit.

f) Please detail the effect that different seasonal conditions could have on the restoration efforts associated with each of these outage scenarios with particular emphasis on the impact to restoration times.

g) If no assessments have been undertaken please provide the rationale for not conducting such assessments.

A. Given the importance of the Labrador-Island Link ("LIL") to the Island Interconnected System, Nalcor Energy Power Supply ("Nalcor") engaged an external consultant, EFLA Consulting Engineers ("EFLA"), to assess the risk of failure of the overhead transmission line in consideration of a variety of scenarios, and to identify equipment and restoration methods that can be used to restore service in the event of a failure.

The results of the EFLA study are included in the following attachments:

- PUB-NLH-054, Attachment 1: "Emergency Response Plan – LITL Transport, Material, Storage Locations and Communication," April 12, 2018;
- PUB-NLH-054, Attachment 2: "Emergency Response Plan – LITL Emergency Line Conductor Selection," March 20, 2018;
- PUB-NLH-054, Attachment 3: "Risk Assessment Labrador Island Transmission Link," April 13, 2018;[1]
- PUB-NLH-054, Attachment 4: "Emergency Response Plan: LITL Event Preparation and Risk Mitigation Measures," March 29, 2018;
- PUB-NLH-054, Attachment 5: "Emergency Restoration Solutions for LITL 350kV Labrador Island Interconnector ERP," April 12, 2018;
- PUB-NLH-054, Attachment 6: "Crew Complement and Training Requirements 350 kV Labrador Island Interconnector ERP," April 12, 2018; and
- PUB-NLH-054, Attachment 7: "Emergency Restoration Plan: LITL – Overland Transmission Emergency Restoration Plan 350 kV Labrador Island Interconnector ERP," April 12, 2018.

The EFLA report considers transmission lines only and does not address the other components of the LIL including ac Terminals, HVdc Stations, and communications

[1] Some of the risks addressed in the study include freezing rain, extreme winds, flooding, erosion, landslides, frost heave, lightning, forest fires, galloping, Aeolian vibration, vandalism, vegetation growth, impact by ground and airborne vehicles, and risks from design and maintenance practices.

equipment. The ac Terminals, HVdc Stations, and communications equipment have been designed to prevent single-component failures causing customer interruptions as further described below. In addition Nalcor has completed a critical spares review and procured critical spares to maintain required availability. In 2020, a business continuity risk review will be completed on these facilities to determine any remedial actions required to mitigate any high level risks identified with these facilities.

a) Extreme Weather

Design of the overhead line portion of the LIL was undertaken using the overhead line design standards in force, namely CAN/CSA C22.3 No. 1 and CAN/CSA C22.3 No. 60826. A significant amount of historical data, including: historical and modern studies, on-site test tower data, as well as local experience when available, was utilized in the determination of the meteorological loading. Eleven different loading zones were identified over the 1,100 kilometre overhead line as part of the optimization of the line design with the construction cost and to account for the unique environmental conditions specific to certain areas. These include various combinations of wind and ice through heavy glaze ice zones, coastal zones, and heavy rime ice (in-cloud ice) zones. Through an iterative process, line design was completed following standard design practices to optimize and reduce line failure risk and to further balance the loads on the structures. The design of the LIL meets CSA 150-year[2] ice and wind loading recommendations for glaze ice zones off the Avalon Peninsula and CSA 500-year[3] ice and wind loading recommendations on the Avalon Peninsula. For rime ice zones, such as the Long Range Mountains, the line design exceeds 500-year designs for both rime ice and wind. Although events such as insulation failure can cause a pole outage, LIL bipole design ensures that in the event of an outage to one pole, the remaining pole is capable of carrying 2.0 pu[4] current overload for 10 minutes, ramping down to 1.5 pu current overload

[2] 1:150-year design provides an annual probability of structural failure due to meteorological loads of 0.7%
[3] 1:500-year design provides an annual probability of structural failure due to meteorological loads of 0.2%
[4] Per unit ("pu").

indefinitely. This ensures that failure of an item that affects one pole will not cause the LIL to be non-operational for an extended period of time.

The calculated annual probability of failure of one or more towers on the overhead transmission line due to extreme weather is considered to be 0.7% for the section designed to a return period of 1:150 years and is 0.2% for the section that is designed to a return period of 1:500 years. In comparison, typical transmission lines within the system are designed for a 1:50-year event, with a 2% annual probability of failure under an extreme weather event. Distribution lines have a higher probability of failure. While an extreme weather event can happen at any time of year, failures causing transmission outages typically occur during the winter season. Given the length of the line, this could occur from October to May. Access to the site can be reached by access road sections, helicopters, snowmobile, or heavy equipment should road access be difficult due to extreme snow. Assuming a loss of a full section of the transmission line (up to 20 structures between anti-cascade structures) the emergency response plan is targeting restoration of monopole operation via emergency structures over a two-week timeframe. The emergency response plan is designed to take limited access into account.

The ac and dc terminal stations were designed for a 50-year lifespan; however, extreme weather events similar to the loading on the LIL overhead line in that area were also taken into account in the design of the stations to reduce the probability of failure of the terminal station equipment for an extended period of time. Depending on the location of a failure in the terminal station, the unlikely failure due to extreme weather could take either a pole or breaker-and-a-third ac diameter[5] out of service, with multiple failures being less probable. Failure of terminal station equipment for one pole will be mitigated by the monopole overload protection. The design of the breaker-and-a-third layout ensures that

[5] An ac diameter includes the equipment between the two bus connections. For a breaker-and-a-third diameter, this includes four circuit breakers and three line connections within the length of the diameter.

failure of an ac diameter would maintain operational flexibility by minimizing the number of common elements (lines, transformers, converters, synchronous condensers, and capacitor banks) forced out of service by the failure. Therefore, there is a low probability of an extreme weather event causing a LIL outage in the terminal stations for an extended period of time. Other than loss of productivity while working in winter weather conditions, which is no different than workers are exposed to today, similar restoration times would be required at any time of year, with typically longer restoration times in extreme cold weather.

b) Line or Terminal Station Equipment Failure

Equipment failure on the transmission line, such as a string of failed insulators, will typically remove one pole from service and will not lead to an extended customer outage. Critical spares stock levels will ensure that equipment is available to complete timely repairs and restore full service for bipole operation. Other than high winds restricting the ability to climb towers or low cloud conditions in mountain zones restricting helicopter access, seasonal conditions will not have a material effect on restoration times. The emergency response plan will be designed to take limited access into account.

The terminal stations at Muskrat Falls and Soldiers Pond have been designed using a breaker-and-a-third scheme as stated in Newfoundland and Labrador Hydro's response to part a. During normal operation, a single failed piece of equipment can be removed from service without affecting other equipment. In the event of a breaker failure (i.e., stuck breaker), two elements are removed from service. Elements are strategically connected so that no two transmission lines, transformers, generators, or filter feeders are removed from service.

Adequate spare equipment will be available for both the terminal stations and submarine cable transition compounds[6] to ensure timely replacement of any failed equipment. Each converter station has a spare converter transformer to allow quick replacement of a failed unit. In addition, there is a spare filter bank for each converter station. Therefore, there is a low probability that equipment failure will cause a LIL outage for an extended period of time.

c) Vandalism

Vandalism on the transmission line is discussed in PUB-NLH-054, Attachment 3. Vandalism on transmission lines in Newfoundland and Labrador is typically limited to individuals shooting insulators. Typically, failures of this type do not cause an outage unless multiple insulators in a string are damaged. In this instance, insulators can be easily replaced, and therefore this activity has a very low probability of causing a LIL outage on the transmission line for an extended period of time.

HVdc Stations, ac Terminal Stations, and submarine cable transition compounds are equipped with security gates and fencing that completely surround the stations to prevent public access. Closed-circuit television cameras have been installed in strategic locations throughout these facilities and can be monitored from various locations. Routine maintenance and inspections are also important in identifying any vandalism activities. Regular inspections can identify damaged equipment and initiate the process for repairs before an outage has occurred. Based on this activity, there is a low probability of vandalism causing a LIL outage for an extended period of time.

[6] The transition compounds are the interact point where the submarine cables at the Straight of Bell Isle transition to the overhead line. There is a transition compound on either side of the Straight of Belle Isle.

d) Cybersecurity Attack

Nalcor's cybersecurity risk protocols and mitigations are currently being implemented for these assets. A detailed risk assessment has not yet been completed for communications infrastructure, ac Terminals, and HVdc Stations. Cybersecurity attack will be included in that analysis.

e) There are other possible but likely less probable events that can cause the LIL to be non-operational for an extended period of time. Although earthquakes are possible and have occurred in the past, according to Natural Resources Canada they pose a very low risk to Newfoundland and Labrador.[7]

Transmission line design has incorporated the required aircraft notification markers to minimize the potential of contact with aircraft, and the line has not been routed within aerodrome airspace. In the unlikely event of an aircraft contact, the zone of failure will be limited to one or two towers and therefore restoration efforts should not cause an extended LIL outage.

The submarine cables across the Strait of Belle Isle are installed inside directionally drilled boreholes from land to the ocean floor, emerging at a depth of approximately 70 m. A natural sea berm restricts icebergs greater than 60 m from entering the Straight of Belle Isle. Once on the ocean floor, the cables were laid in the naturally occurring contours (valleys) on the seabed to further protect them. In addition, the cables were then covered in a rock berm in all areas not protected by the directional drilled boreholes to further protect from dropped ship anchors and fishing gear. Nalcor also negotiated a fishing exclusion zone to remove fishing activity from the cable location. As such, fishing activity would be inadvertent and in violation of the exclusion zone and not anticipated to be a regular occurrence. A total of three submarine cables have been installed to provide redundancy. In the

[7] "2015 Seismic Hazard Map Geological Survey of Canada," Natural Resources Canada, November 3, 2017, <http://www.seismescanada.rncan.gc.ca/hazard-alea/simphaz-en.php#NL>

event of damage to the submarine cable requiring significant repair, the LIL can be operated normally with one cable out of service while repairs are carried out using the spare cable stored in Corner Brook.

f) The effect that seasonal conditions can have on restoration efforts is included within responses to parts a to c.

g) A detailed business continuity risk assessment has not yet been completed for communications infrastructure, ac Terminals, and HVdc Stations. As noted above, this will be addressed in 2020.

PUB-NLH-054 Attachments 1 through 7 contain sensitive information pertaining to the security of Newfoundland and Labrador Hydro assets and are not provided.