Q. **Reference: Figure 9 – Alternative 2 Proposed Oxen Pond Terminal Station T1 and T2 Replaced with 250 MVA Transformers – 230 kV Bus Tie Breaker Installed, page 47.**

Please explain the rationale for locating both 150/200/250 MVA transformers T1 and T2 on Bus 2, as opposed to placing one 150/200/250 MVA transformer on Bus 2 and one 150/200/250 MVA transformer on Bus 5.

A. The following is an explanation of the rationale. Proper system grounding is necessary to ensure adequate short circuit currents to detect a faulted phase conductor, thereby enabling protection systems to operate to isolate the fault and prevent damage to surrounding equipment. It has been a long standing practice that the system grounding at Hardwoods and Oxen Pond Terminal Stations be configured such that during peak load conditions (i.e. all generation in service) the three phase short circuit level on each of the Hardwoods and Oxen Pond 66 kV buses be equal to or greater than the line to ground short circuit level. To this end the transformer winding configurations at each station are critical in maintaining this practice. Having too many ground sources on a bus can result in the line to ground short circuit level exceeding the three phase short circuit level.

At present the 66 kV system grounding at Oxen Pond is provided by the 66 kV ZIG-ZAG-GND winding of the grounding transformer GT1 connected to Bus B2 and the 66 kV ZIG-ZAG-GND winding of 230/66 kV transformer T3 connected to Bus B5. The ZIG-ZAG-GND winding of T3 includes a 4 Ω neutral grounding reactor to ensure that the three phase short circuit level is greater than the line to ground short circuit level. Having a ground source on each side of the 66 kV bus tie circuit breaker B2B5 permits operation of one 66 kV bus (i.e. B2 or B5) with the other 66 kV bus (i.e. B5

or B2) out of service. The 66 kV windings of 230/66 kV transformers T1 and T2 are DELTA and therefore do not contribute to the line to ground short circuit level on the Oxen Pond 66 kV bus. The resultant three phase and line to ground short circuit levels on the Oxen Pond 66 kV bus equal approximately 1,515 MVA and 1,400 MVA respectively.

At Hardwoods 66 kV system grounding is provided by the 66 kV WYE-GND windings of grounding transformer GT1 and 66/13.8 kV transformer T5 on 66 kV Bus B7 and by the 66 kV ZIG-ZAG-GND winding on 230/66 kV transformer T4 on Bus B8. The ZIG-ZAG-GND winding of T4 also includes a 4 Ω neutral grounding reactor to ensure that the three phase short circuit levels exceed the line to ground short circuit levels on the Hardwoods 66 kV bus. The 66 kV windings on the 230/66 kV transformers T1, T2 and T3 are DELTA and therefore do not contribute to the line to ground short circuit level on the Hardwoods 66 kV bus. The resultant three phase and line to ground short circuit levels on the Hardwoods 66 kV bus equal approximately 1,680 MVA and 1660 MVA respectively.

For cost estimate purposes Hydro decided to estimate the cost of replacing both 230/66 kV (WYE-GND/DELTA) transformers T1 and T2 with 250 MVA rated transformers of like winding configuration and defer the impact of replacing and relocating existing Oxen Pond T3 on 66 kV system grounding until final design. The end result at the budget proposal stage is no change in the 66 kV system grounding at Oxen Pond. Moving the “spare” 125 MVA transformer (old Oxen Pond T2) to Hardwoods to replace existing 66 MVA Hardwoods T1, results in no change in the 66 kV system grounding at Hardwoods. However Hydro realizes that the changes result in both new 250 MVA transformers at Oxen Pond on located on the same side of the proposed 230 kV bus tie circuit breaker, with the T3 125 MVA unit on the opposite side, a less than ideal arrangement for the two 250 MVA units.

Short circuit analysis completed post proposal submission indicate that replacing Oxen Pond T1 with a 230/66 kV, 150/200/250 MVA, WYE-GND/DELTA transformer and T3 with a 230/66 kV, 150/200/250 MVA, WYE-GND/ZIG-ZAG-GND transformer will result in a three phase short circuit level greater than the line to ground short circuit level on the Oxen Pond 66 kV bus if the T3 ZIG-ZAG-GND winding is equipped with a 4 Ω neutral grounding reactor. In essence the existing 4 Ω neutral grounding reactor associated with the existing Oxen Pond T3 can be left in place for application on the new 250 MVA T3.

Relocating the existing 125 MVA Oxen Pond T3 with its 66 kV ZIG-ZAG-GND winding configuration for replacement of the existing 66.6 MVA Hardwoods T1 with its 66 kV DELTA winding configuration will serve to add a fourth 66 kV ground source on the Hardwoods 66 kV bus. To ensure that the three phase short circuit level exceeds the single line to ground short circuit level on the Hardwoods 66 kV bus analysis indicates that the existing Hardwoods T4 and the new Hardwoods T1 should be equipped with 11 Ω neutral grounding reactors.

Hydro is preparing technical specifications for both the 230/66 kV, 150/200/250 MVA WYE-GND/DELTA and the 230/66 kV, 150/200/250 MVA WYE-GND/ZIG-ZAG-GND transformer configurations and the 11 Ω neutral grounding reactors to assess cost impacts in the final design phase post budget approval.