Q. Please provide all studies, expert opinions and data concerning the impact of icebergs and pack ice on the SOBI submarine cables.

A. The potential for iceberg damage to the SOBI cable was assessed by C-CORE and their report was submitted to the Board as part of the Muskrat Falls Review.

C-CORE's report was filed as Exhibit 35 and is available at http://www.pub.nl.ca/applications/MuskratFalls2011/files/exhibits/Exhibit35.pdf

Referring to Figure 4-29 of the report, the time between contacts for the cables is approximately 1,000 years for a burial depth of 70 metres or greater, based on a mean iceberg rolling period of 10 days.

The decision to use a mean iceberg rolling period of 10 days was discussed in a technical note provided by C-CORE. A copy is provided as DD-NLH-051 Attachment 1.

As the submarine cables are protected in horizontal directional drill (HDD) boreholes to a depth of at least 70 metres, pack ice will have no impact on the submarine cables.

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C-CORE Technical Memorandum

From:	Tony King	**Date:**	March 21, 2014
To:	Keith Drover, Nalcor Energy	**Project #**	271139
		Doc No:	TM-1139-001 v2
RE:	**Effect of Revised Breakout Depth at Forteau Landfall on Cable Risk**		

1 BACKGROUND

C-CORE (2011) presented an iceberg risk analysis for subsea cables crossing the Strait of Belle Isle, comprising part of the Lower Churchill Transmission Project linking Gull Island, Labrador, and Soldier's Pond, Newfoundland. To minimize the probability of iceberg interaction with the cables, directional drilling will be used to avoid placing the cables on the seabed in shallow water depths near the landfalls at Forteau, Labrador and Shoal Cove, Newfoundland. The initial plan was for the cables to exit the bores onto the seabed at 82 m off Forteau and 70 m off Shoal Cove. C-CORE has been requested to assess the effect of reducing the seabed piercing water depth to 75 m off Forteau.

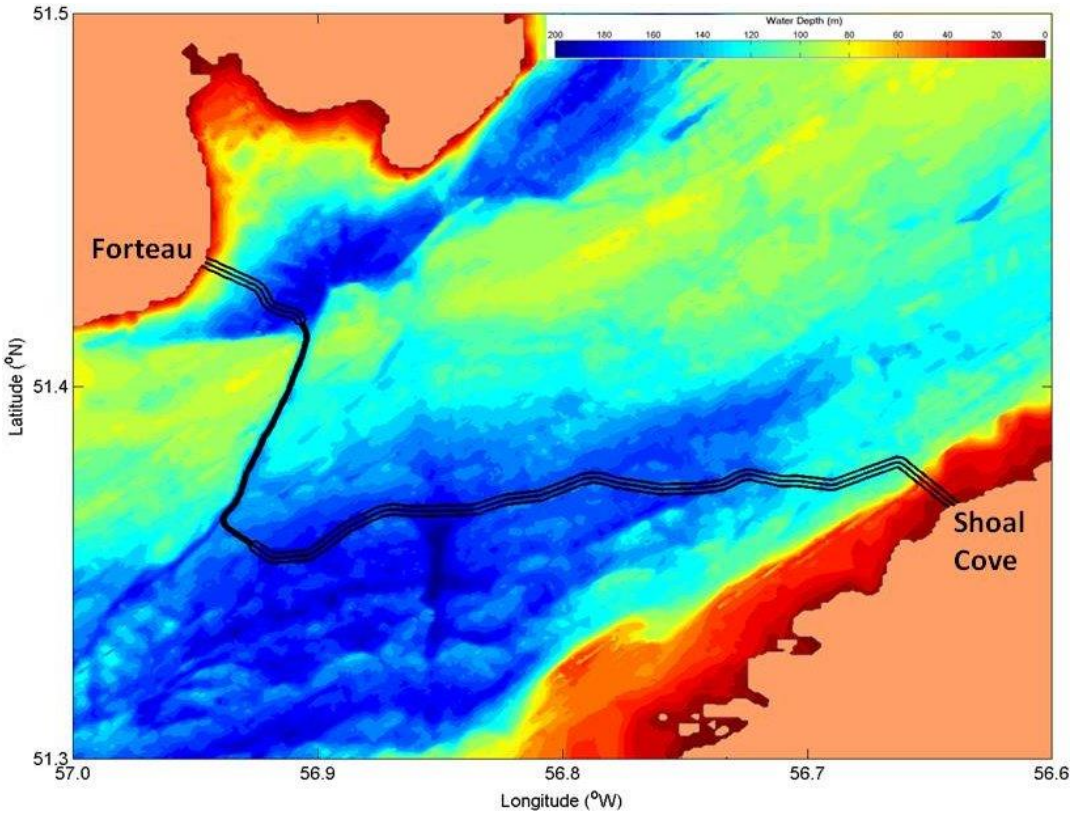

Figure 1. Cable crossing route in the Strait of Belle Isle

2 DESCRIPTION

The iceberg risk analysis used a Monte Carlo model to simulate iceberg movement and groundings at the cable crossing site. The results indicated that iceberg rolling and associated draft adjustments provide a mechanism for icebergs to drift over bathymetric highs and ground on the seabed in areas otherwise considered sheltered from iceberg keels. Table 1 shows the results from the C-CORE (2011) study, with iceberg contact frequency as a function of the iceberg rolling frequency and seabed piercing water depth. It was assumed that the seabed piercing water depth would be the same for both landfalls.

Table 1. Iceberg contact frequency as a function of directional drilling seabed piercing water depth for various scenarios - mean return period in brackets (C-CORE, 2011)

Mean Iceberg Rolling Frequency	Seabed Piercing Water Depth (m)		
	50 m	60 m	70 m
10 Days	0.009 yr^{-1} (110 years)	0.002 yr^{-1} (500 years)	0.001 yr^{-1} (1,000 years)
No rolling	0.006 yr^{-1} (160 years)	0.0001 yr^{-1} (10,000 years)	N.A.

C-CORE (2013) analyzed iceberg observations from the Strait of Belle Isle from the radar/camera installation at Shoal Cove. As most icebergs passed through the area of interest they were photographed at least once with a small number being photographed twice. Icebergs with multiple photographs that were not grounded were examined to determine if an estimated rolling rate was able to be calculated. A total of six icebergs were observed that fit this criteria. None of the six icebergs rolled during the time they were observed, however, the duration of time that passed during which they did not roll is valuable information that could be used to calculate a more accurate rolling rate. Table 2 shows the duration of time that the non-grounded icebergs were observed without rolling, as well as their measured size.

Table 2. Duration of iceberg observations without a rolling event (C-CORE, 2013)

Iceberg ID	Total Time Without a Rolling Event Observed (hours)	Iceberg Length (m)	Iceberg Height (m)
19	45	-	-
41	4	106	17
88	1	42	16
94	6	98	20
100	28	29	10
123	150	170	12

When considering all of the icebergs combined, a total of 234 hours (9.75 days) were observed without a rolling event. This supports the use of a longer period rolling rate (perhaps on the order of 10 days), however additional data collection is recommended to increase the confidence level in this value.

3 RESULTS

The routine used to generate Table 1 assumed the same seabed piercing depths at each landfall. This routine was revised to allow different seabed piercing depths at each landfall. Using piercing depths of 70 and 82 m at the Shoal Cove and Forteau landfalls, respectively, with a 10 day mean rolling period gives 0.00103 iceberg contacts per year, which is rounded to a 1,000 year return period. Using a seabed piercing depth of 75 m at Forteau gives the same result (no change in risk). Figure 2 shows the variation in contact rate with varying seabed piercing depth at the Forteau landfall; no increase in risk is observed until the seabed piercing depth is shallower than 65 m water depth.

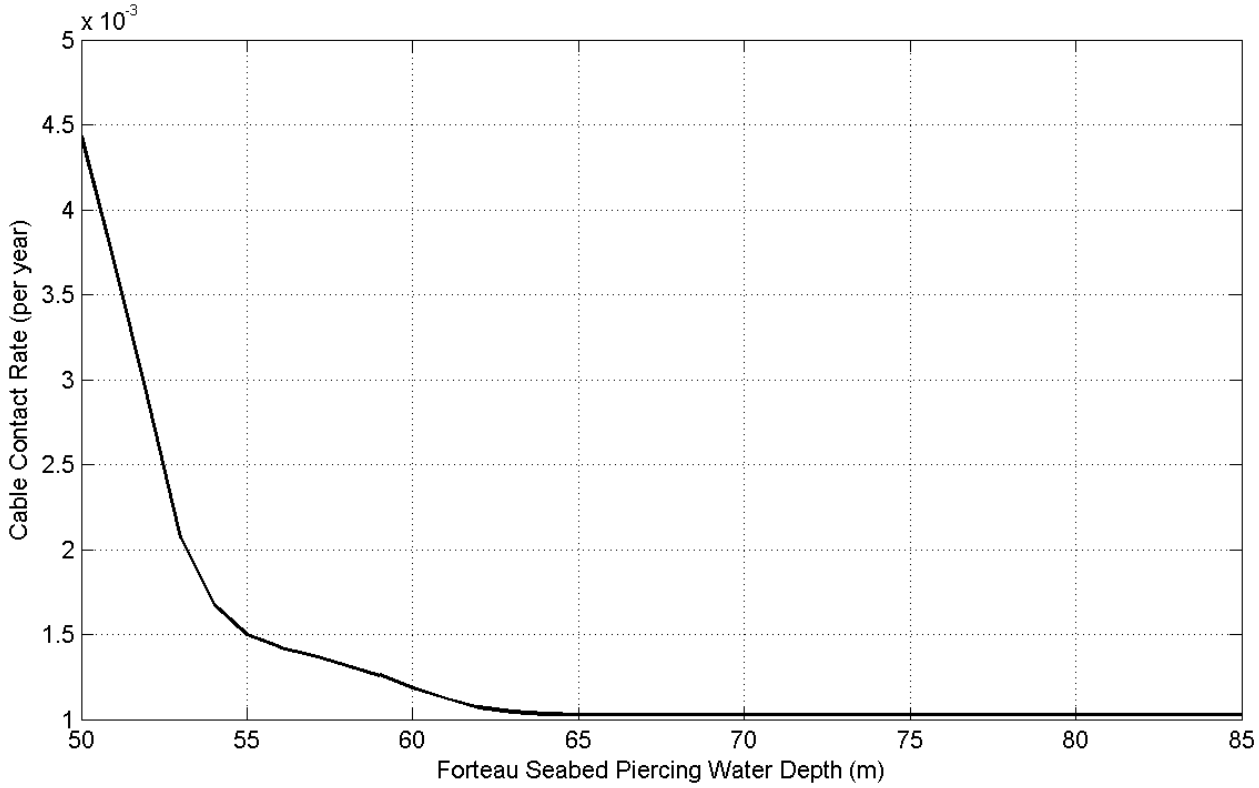

Figure 2. Influence of varying cable seabed piercing depth at Forteau on iceberg contact rate using 10 day rolling period and 71 m seabed piercing depth at Shoal Cove

4 CONCLUSIONS

Reducing the seabed piercing depth to 75 m at Forteau no, or negligible, increase in the iceberg risk to the cable at the Forteau landfall. Additional iceberg observations are recommended to confirm iceberg rolling frequencies. It should be noted that the risk assessment does not include the potential effect of iceberg rise-up (icebergs scouring over the shoals to the northeast of the cable crossing site), although this effect would likely be relatively minor. Since this effect is undefined, it is not recommended to reduce the seabed piercing depth to less than the 75 m value.

5 REFERENCES

C-CORE (2011). Iceberg Risk to Subsea Cables in Strait of Belle Isle. Report prepared by C-CORE and Fugro GeoSurveys Inc. for Nalcor Energy, C-CORE Report R 10 039-781 V3, August 3, 2011.

C-CORE. (2013). Nalcor Iceberg Tracking Radar – 2013 Annual Summary Report, C-CORE Report R-13-064-910, Revision 3.0.