This submission was prepared by Dr. Alain Murphy, a marine geologist with 20 years' experience. Dr. Murphy owns and operates GeoLimits Consulting, specialising in continental shelf delineation and is considered a global expert in the field with clients around the world. Dr. Murphy has had experience analysing geological and geophysical datasets with a specialisation in slope stability and gravity-driven sediment transport. Dr Murphy received a BSc in geology from University College Cork in Ireland and PhD in geology from the University of New Brunswick in 2003.

Dr. Murphy has a family cottage on Caribou Island and has enjoyed many days of recreational boating and fishing in Caribou Harbour. As such, he is very familiar with the coastline, seabed and tidal conditions of the area of the proposed effluent outfall pipe. This submission is Dr. Murphy's independent and professional opinion on the proposed Effluent Treatment Facility by Northern Pulp.

Summary: the geological and geophysical data illustrate that there are too many risks to consider putting a pipeline along the proposed route. Contrary to demonstrating that this is a good candidate for the pipeline routing, the various data highlight multiple mechanisms by which damage could be sustained to the pipeline. These include gravity-driven slumping at the channel edges, greater than normal ice scouring and differential loading pressures on the pipeline due to sediment mobility.

The potential for such a failure to go unnoticed for a considerable period and thereby the effluent not being discharged by the diffuser system is significant. Furthermore, the failure would occur within Caribou Harbour and effluent would potentially remain resident in the harbour for a prolonged period causing considerable environmental damage.

The far-field modelling contains significant uncertainties resulting from limited calibration. The one month duration models show effluent concentration at the mouth of Caribou Harbour as well as impingement of the coastline of Munroes Island and Caribou Point.

Recommendations

Based on the data and analysis contained in both EA document and the Focus Report, it is not clear that a pipeline carrying effluent can be operated safely in the shallow waters of Caribou Harbour. Significant additional research and engineering is necessary to account for and mitigate the hazards posed by ice damage and seabed instability.

The numerical modelling requires significant additional calibration with measured data for the full range of hydrological and meteorological conditions in the Northumberland Strait. Given the risks involved and the potential detrimental impacts to ecosystems and human health, it is recommended that independent third party monitored peer-reviewed oversight of future modelling be conducted. Should the project eventually be approved and proceed, it is recommended that the pipe contain realtime monitoring that is publicly available so that any member of the public can be assured of the integrity of the pipeline at all times.

Were the proposal to proceed, a full federal environmental assessment under the auspices of the Impact Assessment Agency of Canada (formerly CEAA) to access the expertise of the Federal Government is recommended.

Introduction

The focus of this submission shall be on the offshore portion of the proposed pipeline in the region of Caribou Harbour. It is again highlighted that the timeframes for the comprehensive analysis of the data and information contained within the Focus Report is wholly inadequate both for the public and the relevant authorities tasked with assessing the viability of the proposal. For a meaningful assessment of the Environmental Assessment (including the Focus Report) by the regulator, the data should be analysed and interpreted independently to verify those made by the proponent.

The geophysical data demonstrate that the seabed in Caribou Harbour is a highly dynamic marine environment with a number of physical processes operating including:

- Ice scouring
- Slope failure along the edge of the dredged channel
- Shallow sediment de-gassing
- Mobile sediment waves

Two of these are discussed further below.

Ice Scour and Grounding

The Focus Report notes that: *"Caribou Harbour, and the nearby section of the Northumberland Strait, is susceptible to ice scour, predominately due to ice floes. To protect the proposed pipeline from damage due to impact or bearing pressure, the pipeline will be buried to a depth of up to 3 m. Burying the pipeline below the potential scour impact is the most effective measure to protect pipelines from ice damage."* (pg. 43)

The prospect of ice keel damage to the pipeline remains a particular concern and the data presented in the Marine Geotechnical Survey Report (Appendix 2.2, Section 5.5.2) warrants this concern. The report notes that while 15 mapped ice scours had a scour depth of ≥ 0.2 m in water depths of 1 to 6 m, 133 ice scours were mapped and an extensive area of ice grounding was mapped west of Munroes Island with pits of ~0.7 m.

The Receiving Water Study (Appendix 4.2, Section 2.1.2.7) presents data from a DFO helicopter ice survey in February 2013. These data showed that the ice thickness had a mean thickness of approx. 0.7 m. However, the ice keels regularly exceed 2 m in that same dataset (see top panel of Figure 17 of Appendix 4.2). Furthermore, ice thickness surveys conducted by DFO during that same period (28 February 2013) immediately north of Caribou Island documents significantly thicker ice floe thicknesses with keel depths approaching 4 m (Figure 1).

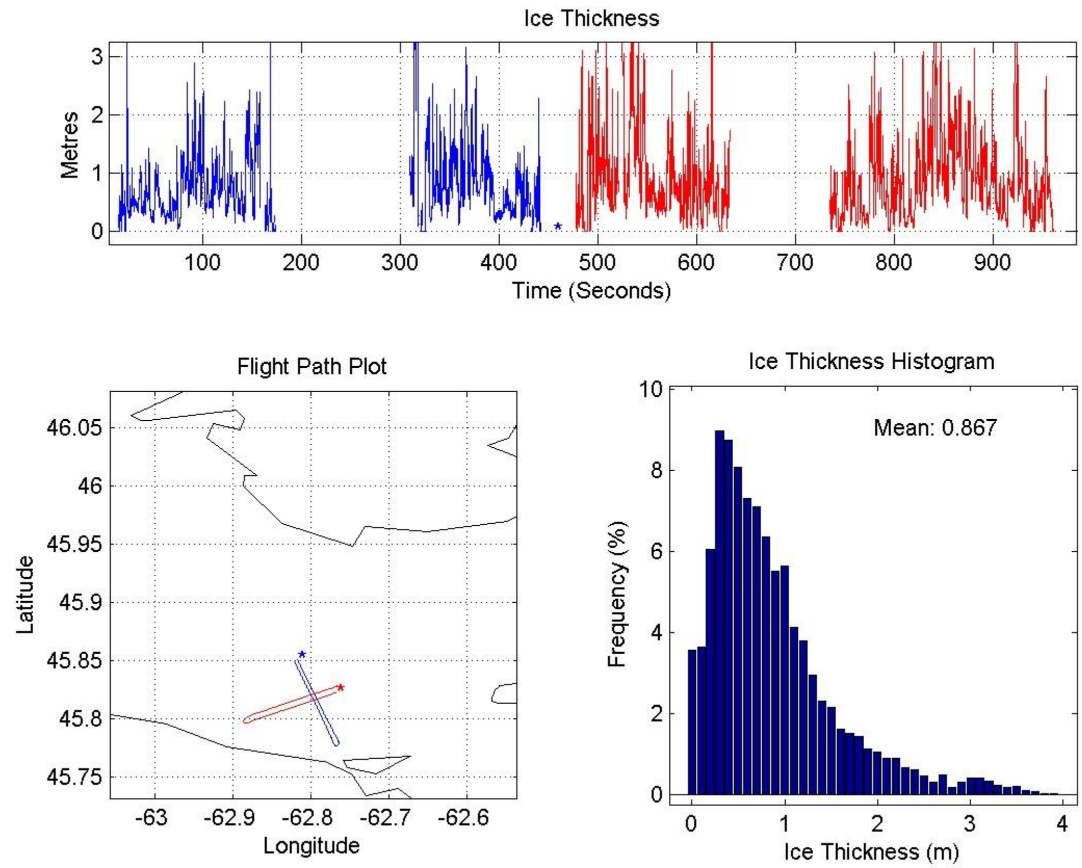

Figure 1: Ice thickness survey conducted by DFO in February 2013 immediately north of Caribou Island. The ice thickness is shown to exceed 3 m at a number of locations. (accessed from ftp://ftp.dfo-mpo.gc.ca/SeaIce/Helicopter_Data/Gulf2013/7%20Gulf%202013%20Pictou%20large%20floe/).

These data are consistent with the values and analysis of Obert and Brown (2011)[1] and the thickness of ice in the Caribou Harbour can approach the burial depth proposed for the pipeline.

There are a number of points of note here:

1. As noted in the Marine Geotechnical Survey Report, the ice scours surveyed were likely formed during the winter 2018/2019 season. As such, this represents a relatively small and time-constrained dataset. The accumulation of ice within Caribou Harbour within any given year is likely to be variable depending on wind speed and direction and tides among other factors. To truly engineer for the possible hazard to ice keel related damage, a more robust dataset is required.

[1] Obert, K.M. and Brown, T.G., 2011. Ice ridge keel characteristics and distribution in the Northumberland Strait. Cold Regions Science and Technology, 66(2-3), pp.53-64.

2. The Marine Geotechnical Survey Report notes the presence of mobile sediment waves particularly in the vicinity of CKP 3 – 3.5 (see Figures 5.3.6 and 5.3.7 of Appendix 2.2). This sedimentological environment would mask the recognition of ice scours. It is clear from adjacent mapping (see Figure 5.5.2) that ice scours are ubiquitous in that region. This region lies beyond the mouth of Caribou Harbour and, in light of the significant thickness of ice keels documented by DFO referred to above, represents a significant risk of damage to the proposed offshore pipeline.
3. The recognition of a region of ice grounding in the vicinity of CKP 1 (see Figures 5.5.5 and 5.5.8 of Appendix 2.2) also illustrates a significant risk to the pipeline beyond the possibility of simple linear ice scouring. The load acting on the pipeline as a result of the weight of grounded ice is a real risk in this region. The evidence of ice grounding shows that this can occur over a significant area (a rough estimate from Figure 5.5.8 would be 75 m^2). It is unlikely that the backfill overlying the pipe could absorb the load acting down on the pipe from a large volume of grounded ice. Given the shallow water depths along the proposed pipeline routing, there are a number of locations where this remains a risk.
4. Another important consideration in assessing ice scour data is the sediment type of the seabed. As noted in the Marine Geotechnical Survey Report, finer sediments such as clay and silt can record ice scours more effectively than sandy or gravelly deposits. Also, sediment reworking can rapidly infill larger scours. A significant portion (~65%) of the surveyed area is made of sand and silty sand and this corresponds to areas where fewer scours have been mapped. This again leads to significant unknowns when trying to assess the impact of ice-related hazard to the proposed pipeline.
5. It is difficult to assess the data from an already interpreted static image but a number of v-shaped reflections, in addition to interrupted reflectors within the CHIRP data suggest a possible greater influence for ice scouring (Figure 5.4.4 of Appendix 2.2). The R1 reflector and sequences SQ2 and 3a show possible evidence of disturbance related to ice scour.

As a result of these observations, a burial depth of 3 m would not seem to represent a mitigation of the risk posed by ice floes (both scouring from the ice keel and grounding of the floe). Any number of processes could damage and rupture the pipeline and, in light of the pipe being buried 3 m, this damage would not be readily accessible or observable. A protracted leak could continue for a long period before being noticed potentially resulting in sustained damage to the marine ecosystem.

Slope Failure

The bathymetry along the proposed pipeline has been well documented in the Marine Geotechnical Survey Report. The area can be classified into two broad categories – a shallow (< 5 m) region punctuated by a channel, sediment waves and ice scours for the landward 2.3 km of the proposed pipeline length, and a rapidly deepening region where depths go from ~2 m at the mouth of Caribou Harbour to ~20 m seaward of the mouth over a distance of ~1000 m.

The proposed pipeline runs approximately parallel to the dredge channel for the Caribou Ferry Wharf. The Channel is dredged to a depth of 5.5 m below low water.

Multibeam bathymetry reveals the scalloped edge to the dredged channel which suggests retrogressive erosion (Figure 2). The eroded sediment undergoes gravity driven transport from the edge of the dredged channel downslope. The slope map in the Marine Geotechnical Survey Report (Figure 5.1.5 of Appendix 2.2) shows gradients exceeding 10° (possibly up to 20°) which, given the sediment type (sand/gravel – Enclosure 8 of Appendix 2.2), represents an unstable mobile seabed.

The proximity (within 20 m) of the unstable dredged channel slope to the proposed pipeline is cause for concern. Were there to be a larger slope failure, the seabed upon which the pipeline lays could give way. Even absent a catastrophic failure, the retrogressive erosion of the channel edge could eventually undermine the sediment base of the pipeline.

This sediment transport is the reason for ongoing dredging activity within the channel. This dredging is described in a project description by Public Works and Government Services Canada from 2017. The location of one of the areas targeted for dredging in that document coincides with the region described above. It seems plausible that this would be required again in the years to come. As such, significant machinery (barge-mounted mechanical dredges) would operate in the vicinity of the proposed pipeline posing a significant damage hazard.

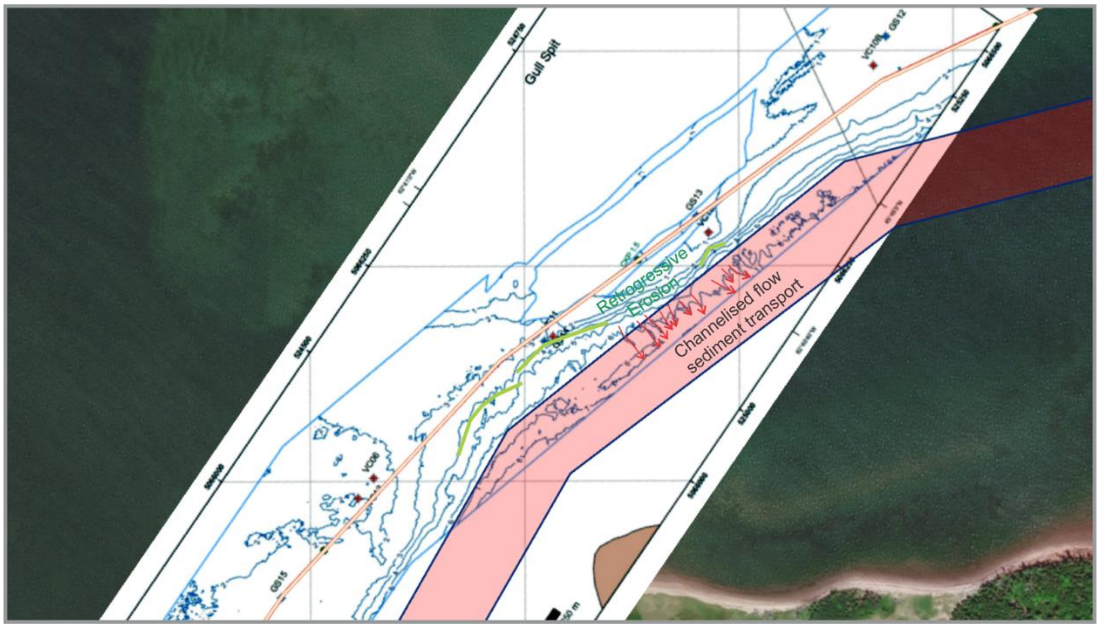

Figure 2: Map prepared for this submission showing the scalloped pattern of retrogressive erosion (in green) and the channelised gravity-driven sediment transport (red) along the edge of the dredged channel (red shading). The proposed pipeline is shown in pink.

Receiving Water Modelling

It has to be remarked that while the quality and level of detail of the modelling contained within the Focus Report is a vast improvement on the modelling contained in the EA registration documents. Nevertheless, there remains significant uncertainties, data gaps and areas of concern. It is impossible to perform an adequate examination of the model within the timeframe provided for in the public comment period. Given the consequences of inaccurate model prediction, it is recommended that a comprehensive and independent peer review of the model is conducted.

It should be noted that a numerical model of any system is a non-unique solution. Input parameters are changed to calibrate the model. The more complex a model, the greater number of parameters that are variable and consequently the greater the chance it departs from the physical reality of what it seeks to simulate. To test the validity of the numerical model, model prediction outputs are compared against measured observations over time. The short time period since the generation of the model (essentially summer 2019) to test predicted versus observed data reduces confidence in the model.

A major deficiency concerning the input parameters for the far field modelling is that the input data used to calibrate the model were acquired over the course of one season – and in many cases only over two days (May 24 and 25, 2019). This includes the determination of the temperature and salinity profiles of the water column (see Figures.12 and 13 of Appendix 4.2 for example).

This represents an inadequate dataset upon which to make model predictions in the Northumberland Strait, particularly in the Caribou Harbour region. Even over the course of a summer season, there is significant variation in the surface temperature of the water. This is more pronounced in winter when the strait freezes over and clearly a temperature and salinity profile would be very different.

The simulation periods, as outlined in Table 11 of Appendix 4.2, are the months of July and February 2019, while the model has only been calibrated for May/June 2019.

The effluent dispersion modelling also contains assumptions that raise questions as to its usefulness. There is no detailed explanation in Section 2.3.2.4 of Appendix 4.2 of what the what the “assumed arbitrary concentration” is. Assumptions of “typical mill effluent” of 900 – 1500 mg/L is given in Table 11 without any citation or relation to whether this is realistic for the Northern Pulp mill.

The model predicts “little plume intrusion into Caribou Harbour”. Local knowledge of Caribou Harbour, however, confirms that under certain (current and wind) conditions significant surface organic debris can be transported into the harbour and remain over a number of days indicative of significant flow into the mouth of the harbour. Furthermore the deposition of Gull Spit is due to inward flow into Caribou Harbour with sediments being deposited on the lee side of Caribou Point.

The simulated effluent concentration maps predicted by the model seem unrealistic when considering a continuously discharging source with seemingly isolated pockets of higher concentrations of effluent isolated in the model domain. Even if one assumes the model is accurate, there would appear to be issues with increased effluent impacting the coastline. Figure 33 of Appendix 4.1 shows high concentrations of effluent on Munroes Island. It is recalled that Munroes Island is a designated Provincial Park and Section 24 of the Provincial Parks Act (R.S., c. 367, s. 1) states:

"No person shall transport garbage, refuse or domestic, hazardous or industrial waste through, over or in any provincial park or deposit such material in or on a provincial park, except as may be authorized by permit issued by the Minister."

Figure 38 of Appendix 4.2 is most concerning. Again, if the model is accurate (something that is questionable given the assumptions and constraints), the simulated effluent concentration after only one month shows a build-up in the vicinity of the mouth of Caribou Harbour. One can only assume this increases over time.

The Winter modelling is poorly constrained by measured data. There is no examination as to whether there is any stratification of the water column which would greatly impact the way in which plume dispersal would occur. The simulated effluent concentrations in Figure 45 shows again a significant concentration build-up after a one month period albeit further southeast. It also shows a high concentration on the coast by Caribou Point.

A variety of shellfish are harvested within Caribou Harbour in the intertidal areas (e.g. oysters, mussels and quahogs) by residents (my own children have often consumed raw shellfish (oysters) right off the beach as well as cooked razor clams, mussels, and quahogs), visitors and semi-commercial fishers. These are filter feeders and would readily incorporate contamination from the discharged effluent. The risk to human health is real and potentially severe. Given the uncertainties surrounding the behaviour of the effluent plume in this location, caution is essential.

Concluding Remark

As proposed, the marine portion of the Effluent Treatment Facility proposed by Northern Pulp contains too much risk to the marine environment and human health. Uncertainties concerning the integrity of the pipeline and the behaviour of the effluent discharge under normal operating conditions remain high.

The actions needed to address and possibly mitigate these risks are time and cost intensive. It would be beneficial, therefore, to have a full federal environmental assessment under the auspices of the Impact Assessment Agency of Canada (formerly CEAA) to access the expertise of the Federal Government.